The choice of abatement method is determined mainly by the condition of the ACM. Surfacing materials can be removed, encapsulated with sealant, or enclosed within an airtight structure. The three methods are summarized in Table 3 and described in more detail in Section 5.1. Worker protection and the construction of sealed containment barriers around the work site are required for all three methods.

Removal has the widest applicability. It also is the only truly permanent solution, since no building containing asbestos can be demolished without first removing the ACM. If ACM has only minor, isolated damage, removal of selected areas may be sufficient.

Enclosure and encapsulation have limited application. Enclosure is restricted to situations where ACM can be isolated in small localized areas. Encapsulation can be used only for acoustical plaster in good condition. In addition, the special O&M program must be continued and the enclosed or encapsulated materials reinspected periodically (at least monthly) until the ACM is removed or the building is demolished. Encapsulation may make eventual removal more difficult and costly, since encapsulated ACM may have to be removed in dry form.

Initial cost of removal may be higher than for other abatement methods. However, removal may be less expensive over the long term, since the continued presence of ACM requires special O&M practices, periodic reinspection, and repairs. Enclosure and encapsulation are options only when the ACM is in good condition. These are primarily temporary measures to reduce the potential for future disturbance or erosion until the ACM is eventually removed.

4.2.2 Pipe and Boiler Insulation

4.2.2.1 Need

Pipe and boiler insulation typically presents a more localized fiber release problem than surfacing material. The insulated pipes, boilers, ducts, and other equipment are frequently confined to equipment rooms or placed within walls or behind ceilings. Even accessible insulation is localized to the piece of insulated equipment. Thus, the potential for disturbance, damage, or erosion is lower than for surfacing material; frequent inspection can spot any new disturbance and the damage can be repaired quickly. The condition of the ACM determines the need for further action (see Table 4). If the insulation is intact, no further action is needed.

4.2.2.2 Timing

Damaged insulation should be repaired or replaced as soon as possible. Major renovation, such as installation of a new boiler, is a good time to consider replacing pipe and boiler insulation with non-asbestos material. This will eliminate the need for a continuing special O&M program.

4.2.2.3 Method

Removal is appropriate where the insulation is extensively damaged or deteriorated. It involves cutting and stripping the insulation from pipes (or other equipment) and substituting non-asbestos material. Plaster around elbows, valves, and flanges should also be replaced with non-asbestos materials. Removal of pipe and boiler insulation requires many of the same precautions and worker protection measures for removal of surfacing materials.

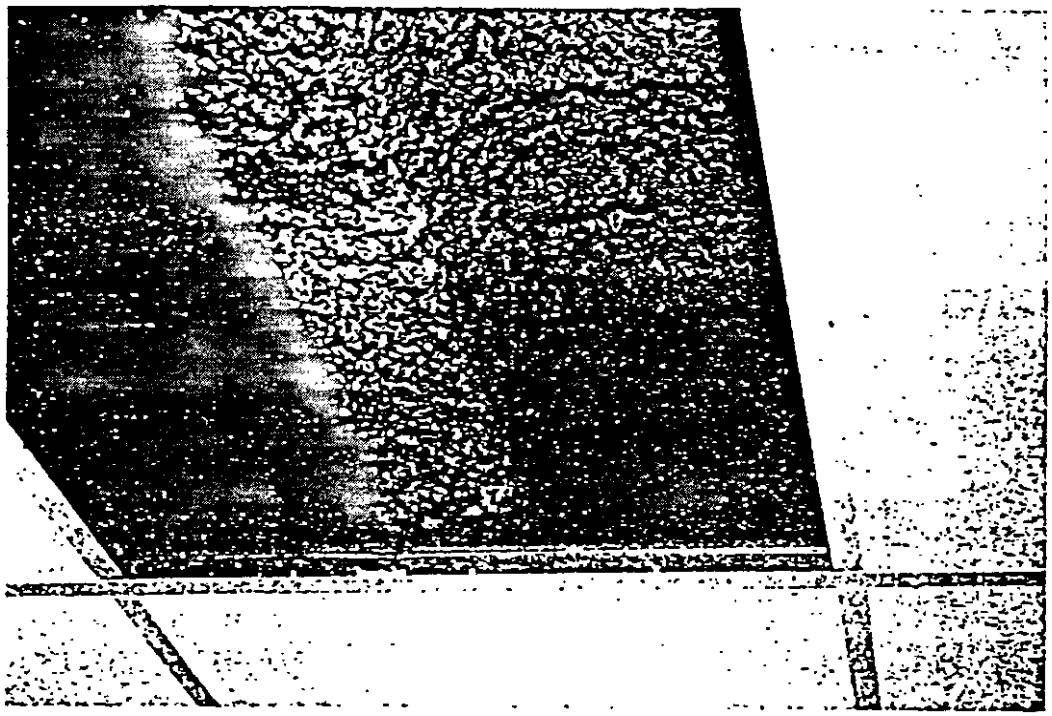


Figure 9. Asbestos-containing material located above a suspended ceiling.

are required for removal of ACM and are highly recommended for other abatement methods, since enclosure

The third common feature is proper work area containment. Containment typically means construction of barriers with 6 mil polyethylene plastic sheets joined with folded seams, and with sealing tape at the seams and boundaries. Some contractors have had problems attaching plastic sheets to walls. Thinner sheets or a better attachment system (for example, stapling and taping sheets to furring strips fastened to walls) may be required. (Figure 10 shows the construction of a typical containment system. Note that respirators should be worn if the ACM will be disturbed during construction.) Air locks and worker decontamination facilities with showers are recommended, as well as negative air pressure systems, described in Section 5.1.1 below.[2] All return air vents should be sealed to prevent asbestos contamination of the air-handling system. Without such containment measures, increased exposure for building occupants is likely. Once abatement begins, everyone not participating in the project should be kept out of the area.

The fourth common feature is the need for a rigorous postabatement cleanup. This includes wet-mopping or HEPA-vacuuming all horizontal and vertical surfaces in the work area. (Wet mopheads and cloths should be discarded in sealed plastic bags and treated as asbestos-contaminated waste.) Cleaning of surfaces outside the work area is highly recommended. Two cleanings—the second after at least 24 hours when suspended fibers have settled—will provide better assurance of fiber reduction than a single cleaning. (Section 6.4 contains additional information on cleaning and inspecting the work site.)

5.1.1 Removal, Disposal, and Replacement

Figure 11 is a photograph of a typical removal project. When removing ACM, observe the following requirements:

- The material must first be treated with a solution of water and a wetting agent to reduce fiber release. Some types of amosite-containing materials will not absorb either water or water combined with the wetting agent suggested by EPA (50% polyoxyethylene ester and 50% polyoxyethylene ether). Other wetting agents should be tested on the material for absorption. If the material will not absorb the wetting agent, undertake a dry removal using Type C respiratory protection. EPA must approve all dry removal operations. Get in touch with the NESHAPS contact in your region (see Appendix D).

- Friable ACM must be disposed of in "leak-tight containers," typically 6 mil polyethylene bags. Bags can be placed in 55-gallon drums for additional protection. Bags or drums must be labeled, as specified by NESHAPS (see Appendix C) or OSHA (see Appendix F).

- OSHA procedures for worker protection and decontamination, as well as for measurement of airborne asbestos, must be strictly followed (see Appendix F). While not required by law, EPA procedures for work area containment should also be followed to assure safe removal.

Research on asbestos removal plus EPA's experience with removal activities in schools since 1979 have pointed up several other important issues:

- A tear in the containment barrier is a significant exposure hazard for building occupants and should be repaired immediately. The use of negative pressure systems together with HEPA filtration (that is, low speed exhaust fans with HEPA filters) to move air from within the work-area

[2] OSHA decontamination requirements specify worker change rooms as a minimum provision for asbestos removal projects. If negative air systems are used, "air locks" should not be airtight. That is, make-up air should pass through the air lock. See Appendix J for additional information.

Figure 10. Construction of containment barriers.

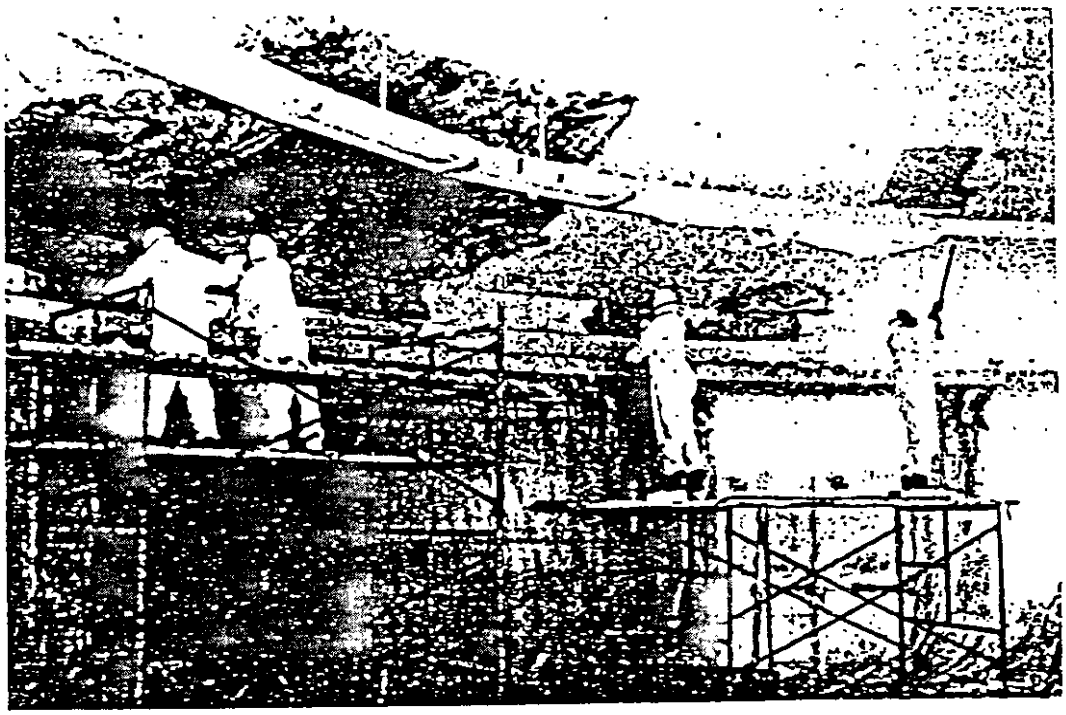


Figure 11. An asbestos removal project.

to outside the building will provide added protection in case of an accident. Appendix J summarizes specifications for negative air systems.

- When containment barriers are dismantled after ACM removal, the sealing tape used to attach the plastic sheets to walls and ceilings frequently removes paint. It is prudent to include the cost of repainting all walls (and ceilings, if appropriate) in estimates of asbestos removal costs.

- Asbestos waste is sometimes spilled both in and outside the work area. Containers full of wet material are very heavy and hard to transport. These containers must be sealed and handled carefully. Workers should continue to wear protective equipment during these operations. Also, disposal sites may be scarce. Some states require a disposal permit before removal begins.

- Amended water (water and wetting agents) from spray operations may leak through the polyethylene sheets and damage floors, especially tile and wood. Sealed double plastic sheets should protect the floors.

When removal and disposal operations are finished, evaluate the need for a sealant on the exposed surface. (The need to reinsulate or resoundproof with asbestos-free materials should be decided before removal begins.) Sealants generally are necessary where the underlying surfaces are porous (for example, concrete blocks or slabs), since a few fibers usually remain after removal.

Cost of asbestos removal varies widely by region and by job. Where the underlying surface must be sealed and the ACM replaced, those costs must be added to removal costs.

5.1.2 Enclosure

Enclosure involves construction of airtight walls and ceilings around the ACM. Figure 12 shows a typical enclosure. These recommendations for constructing enclosures should be followed:

- To reduce fiber release, drills used during installation should be equipped with HEPA-filtered vacuums.

- Underlying structures must be able to support new walls and ceilings.

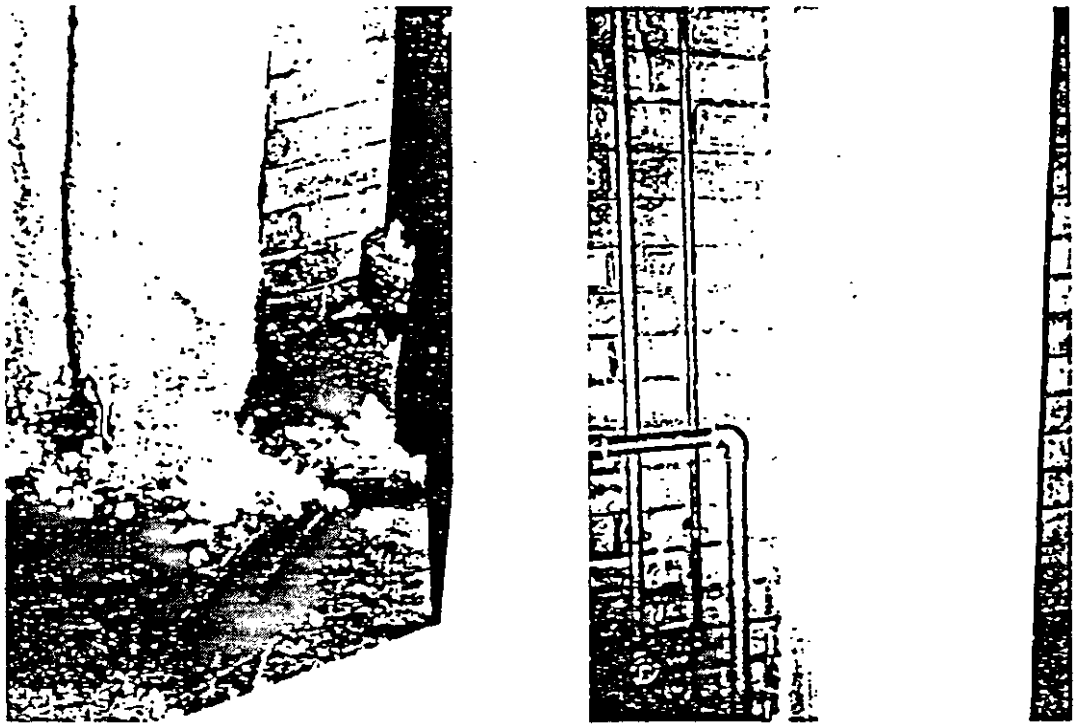
- New construction material should be impact-resistant and assembled to be airtight.[3] Gypsum panels taped at the seams, tongue-and-groove boards, and boards with spline joints all qualify. Suspended ceilings with lay-in panels are not acceptable. Joints between walls and ceilings should be caulked.

- If lights are recessed into ACM, they must be removed carefully to minimize fiber release. Lights should be reinstalled beneath the new ceiling.

- Relocation of plumbing lines and computer cables may be necessary.

- Building records must note the presence of asbestos behind the enclosure to prevent accidental fiber release during remodeling or building demolition. (The presence of ACM should have been documented as part of the special O&M program.) Signs should be posted, noting that ACM is behind the enclosure.

[3] No enclosure will be totally airtight. The practices recommended here are designed to greatly reduce air movement across the enclosure boundary.



Before enclosure

After enclosure

Figure 12. An asbestos enclosure project.

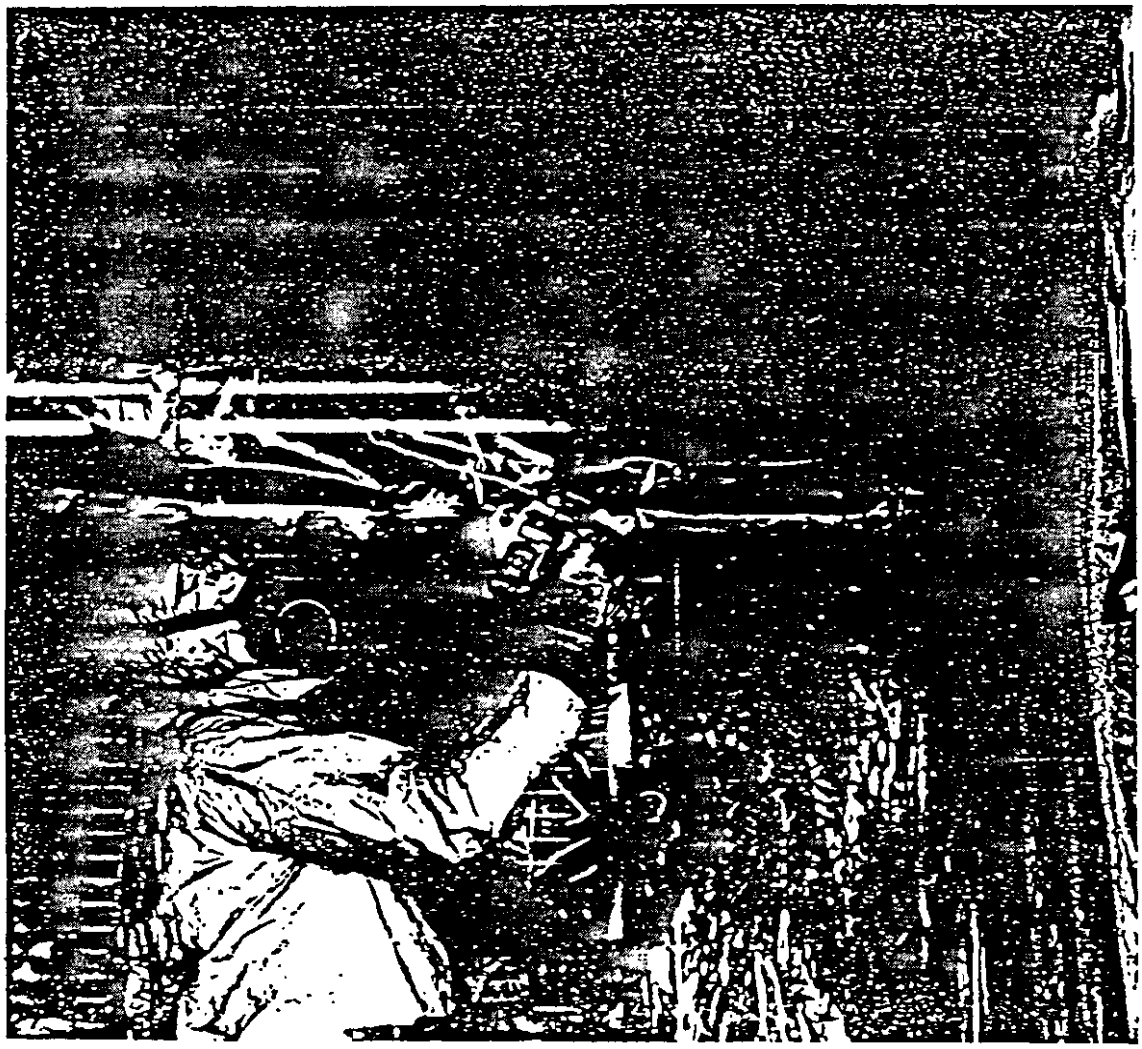


Figure 13. An asbestos encapsulation project.

Armholes and an inside pouch for tools let the worker remove insulation without [illegible]

the bag with a HEPA-filtered vacuum.[6] Workers who use containment bags should still wear respirators in case a bag leaks.

To remove individual pipe sections or an entire pipe network, a small section (about 6 inches wide) of insulation should be removed. The pipe then can be cut into manageable lengths with a saw or torch. Exposed ends of the insulating material should be sealed with plastic and tape. If the remaining insulation is not in good condition, the entire pipe should be wrapped in 6 mil plastic. Disposal of insulation material must follow EPA procedures discussed earlier for ACM disposal (Sections 1.4 and 5.1). More information on pipe and pipe insulation removal will be provided in a future technical bulletin.

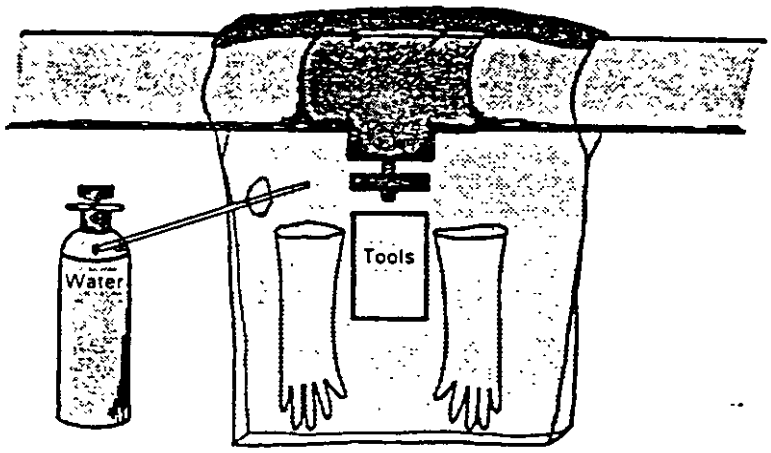


Figure 14. Custom containment bags for repairing or removing pipe insulation.

5.3. Abatement Methods for Other Types of ACM

Additional corrective action generally is not needed for other types of ACM. The special O&M program should continue until building renovation or maintenance requires ACM removal. The ACM should then be removed following the guidelines for surfacing materials (i.e., worker protection and work area containment). Removed ACM should be wrapped in 6 mil plastic sheets or placed in plastic bags, labeled as asbestos waste, and transported to a solid waste site. Unless these materials are friable, OSHA and NESHAPS regulations covering removal operations do not apply.

[6] Seals can be checked with a flashlight and smoke from a smoke tube.

Because efforts to treat ACM may be hazardous to abatement workers and building occupants, careful planning and diligent implementation of the project are essential. Removal, enclosure, or encapsulation of surfacing materials and removal or repair of pipe and boiler insulation may cause large-scale fiber release if proper procedures are not followed. As a result, asbestos levels in the building may increase rather than decrease.

For this reason, key elements of the abatement project include comprehensive and precise contract specifications, workers specially trained in asbestos abatement, rigorously applied worker protection and site containment measures, and the regular monitoring of the work site. When abatement activity is complete, the entire work site should be thoroughly cleaned. The contractor should be released only after the work site has passed visual inspection and a test for airborne asbestos.

SUMMARY

Who Should Do the Work:

Usually a contractor is hired to conduct abatement work that goes beyond special O&M. Occasionally, a large school district or an owner of many buildings will train and dedicate an in-house asbestos abatement team.

Selecting a Contractor:

Steps in selecting a contractor include checking references, conducting interviews, reviewing insurance coverage, and writing precise contract specifications. Note that the most cost-effective contractor is not necessarily the lowest bidder.

Managing the Work:

- Regular on-site inspections will assure conformance with work specifications and avoid costly and hazardous errors.
- Before the contractor is released, the work site should pass both a visual inspection and an air test for asbestos fibers to be sure the site has been adequately cleaned. From a technical point of view, the TEM method is preferred for the air test. Although the PCM method is not as specific for asbestos nor as sensitive to thin fibers as the TEM method, it is frequently more available and easier to implement.

6.1 Who Should Do the Abatement Work

Employees involved in the abatement work must be specially trained and committed to quality work. Training should:

- Familiarize workers with the general problems of airborne asbestos;
- Teach them to handle ACM safely and prevent unnecessary fiber release; and
- Explain how to interpret asbestos abatement work orders.

Either in-house staff or outside contractors can conduct asbestos abatement work. The decision depends primarily on training, equipment, and experience.

In most cases, the in-house maintenance staff will not have enough time to master asbestos

with many buildings containing surfacing ACM have formed asbestos abatement teams whose sole responsibility is control of ACM. These in-house teams can thoroughly learn the requirements and methods of asbestos abatement. With this training and knowledge of the buildings, an in-house team may be the most effective. More typically, however, an outside contractor specializing in asbestos abatement is hired for specific abatement projects.

Building maintenance workers accustomed to repairing equipment with insulation are frequently trained to undertake abatement actions involving pipe and boiler insulation. However, outside contractors are typically hired to remove extensive amounts of insulation or to remove both pipe and insulation.

6.2 Selecting a Contractor

Selecting a competent contractor is the first step toward successful abatement. EPA's experience with asbestos abatement and comments from technical advisors suggest that many contractors cannot properly conduct abatement projects. Several contractors, awarded jobs based on responsive and reasonable cost bids, proved unable or unwilling to follow contract specifications. Suggestions to help building owners avoid these situations are as follows:

- Assign the technical advisor who will monitor the abatement work to assist in writing job specifications and selecting the contractor. The advisor should not be employed by an abatement contractor.
- Require evidence of prospective contractors' experience and/or training in asbestos abatement.
- Check references, including other building owners for whom contractors have worked. (See Appendix K for an example checklist of contractor qualifications.)
- Ask for detailed written descriptions of how bidders will satisfy the project specifications.
- Interview bidders regarding their work, worker protection, and site containment plans. A statement that the contractor will comply with all EPA, OSHA, and state regulations is not sufficient. Ask bidders for copies of their standard operating procedures and employee protection plans, specifically their OSHA medical monitoring and respirator training program. The interview is invaluable for evaluating each contractor's capabilities and understanding of the problem.
- Obtain documentation of each contractor's fiscal qualifications, including financial performance, assets, liabilities, legal judgments, and insurance.
- Be sure that the contractor selected has adequate liability insurance. Some forms of insurance may not provide enough long-term protection against inadequate abatement work. The building owner's attorney and insurance advisor should determine if coverage is adequate.
- Be specific about what constitutes successful job completion. A thorough visual inspection to insure adequate cleaning is an absolute necessity. Air monitoring is also recommended (see Section 6.4). The person carrying out the air monitoring should not be employed by the abatement contractor.
- Require evidence of worker certification or have the contractor conduct an on-site training program for workers.

- Encourage bidding competition, since prices can vary greatly. Multiple bids are desired, but minimization, is the goal.

- If possible, avoid contracting for abatement work during the summer. Many school projects are conducted during that season, taxing the limited number of competent contractors.

Appendix L contains a list of organizations that have prepared model contract specifications for asbestos removal. Together with the above suggestions, these models can serve as the basis for writing specifications tailored to individual projects. Remember that EPA's RAC can provide additional information and suggestions.

6.3 Managing the Work

As in all construction jobs, the program manager or the manager's representative (frequently the technical advisor) should visit the abatement work site often (no less than four times per day) to insure that all plans and procedures are properly implemented. The work site monitor should:

- Be sure the workers follow specifications;

- Confirm compliance with worker protection requirements; and

- Assure that the containment barriers around the work site are properly constructed and maintained.

By carefully monitoring the abatement work, the asbestos program manager can correct errors quickly. Work site inspections are most effective if the manager can refer to a detailed workplan containing specific work practices. Where work does not follow specifications, the project should be stopped immediately. The abatement contractor, the asbestos program manager, and the work site monitor (if different from the program manager) should then identify the problems and take steps to correct them.

The need for worker protection (protective clothing, respirators, and change facilities) was discussed in Section 5.1. Although contractors are responsible for their employees, a building owner's concern for the safety of everyone in the building extends to the abatement workers.

Work area containment is essential for all types of abatement and for both surfacing material and pipe and boiler insulation. Once abatement begins, all persons not directly involved in the work should be barred from the area. The work site monitor should make sure plastic barriers are in place (see Section 5.1) and that warning signs are posted at least 20 ft. in front of the work site entrance.

If abatement activity is limited to repair or minor removal of pipe and boiler insulation, containment bags will probably be used (see Section 5.2). The monitor should inspect the construction and use of the bags. Warning signs should be posted outside the work site.

The monitor should also check the air lock at the entrance to the work site. If a negative pressure system is not used, the air lock (and the entire containment system) should be airtight. If a negative pressure system is used (as recommended), the air lock must allow air from the building to enter the work site to replace the contaminated air that is filtered and exhausted outside. When inspecting the work in progress, the monitor's specific checklist will depend on the type of abatement. Abatement inspection for surfacing materials and pipe and boiler insulation should be based on guidelines and precautions described in Chapter 5 (Sections 5.1 and 5.2, respectively).

Work site inspections greatly increase an abatement project's likelihood of success. The importance of doing the job right the first time cannot be over-emphasized. Tests must be performed when the work is

finished to determine if the project has been conducted properly and the work site adequately cleaned (described in 6.4.) However, if the workers have not been diligent throughout the project, proper cleaning of the work site may not be possible.

6.4 Releasing the Contractor

An asbestos abatement project is successful when the source of fiber release has been controlled and airborne asbestos generated during abatement has been reduced to an acceptable level. As discussed earlier in this chapter, success can be built into the project with a sound work plan and constant monitoring of the work area to insure proper implementation. All workers must be trained and must follow stipulated work practices. Also, it is important to use negative air pressure ventilation to capture asbestos fibers generated during all types of abatement, and to continually remove debris from the site. When the abatement project is completed, the entire site should be cleaned at least twice.

Success is confirmed with a final evaluation at each work area. The evaluation consists of visual inspection and air testing. Visual inspection is used to determine if the work has been performed properly and to check for debris and other obvious signs of poor cleaning. Air testing helps confirm that the work site has been adequately cleaned. Only then is the contractor released.

6.4.1 Visual Inspection

The primary test for releasing the contractor is a thorough visual inspection of the work site. The inspection should be conducted before the containment barriers have been taken down but after the plastic sheets have been cleaned with damp mops and cloths or a HEPA vacuum cleaner. Since elevated levels of airborne asbestos may still be present, the inspector should wear a respirator (see Section 5.1).

First, the inspector should confirm job completeness. If ACM has been removed, substrate surfaces should be checked to be sure no ACM remains. Special attention should be given to pipes, beams, and irregular surfaces that may have corners and hard-to-reach areas. If the materials were enclosed, check the area for tight construction (e.g., no stray drill holes or openings at corners). Inspect encapsulated surfaces to insure that the right amount of sealant has been used: there should be no holes, voids, or cracks. Check surfaces behind obstructions (e.g., pipes or ducts) for these signs.

Next, the inspector should determine that the work site has been adequately cleaned. Any activity that disturbs ACM will release fibers. Therefore, work site cleanup after removal, repair, enclosure, or encapsulation is critical.

Examine all surfaces for dust and debris, especially overhead areas like tops of suspended light fixtures. Use a damp cloth to collect dust from these surfaces and then inspect the cloth for evidence of dust. This is a practical way to establish that the "no dust" requirement has been met.

A more sensitive test for dust is to darken the room and shine a flashlight so that the beam just glances any smooth horizontal surface. Run your finger across the illuminated area. If a line is left on the surface or if airborne particles shine in the light, dust is still present.

If dust is found by either of the two tests, the entire work area should be recleaned and the tests repeated.

6.4.2 Air Testing

Conduct air monitoring only after the site has passed visual inspection. First, remove all plastic sheets covering floors, walls, and other surfaces. (The plastic barriers separating the site from the rest of the building

and the plastic sheets covering doors, vents, and windows should be left in place until the air test has been passed.) If a negative air pressure ventilation system was used during abatement, it should continue operating while air monitoring is in progress.

As discussed in Section 4.1, measuring airborne asbestos fibers accurately is technically complex and usually expensive. It involves two steps: air sampling to capture fibers on a filter, and laboratory analysis to determine the quantity of asbestos. There are several approaches to air sampling and analysis, varying in technical requirements, cost, and availability. Which approach is more appropriate is a controversial subject. The information presented in the remainder of this chapter is based in part on a 1984 workshop sponsored by EPA and the National Bureau of Standards. A companion EPA guidance document on air monitoring following an abatement action discusses the subject in more detail (USEPA 1985b).

6.4.2.1 Sampling

Sampling for asbestos consists of collecting fibers by drawing air through a filter at a known rate. Usually, sampling equipment is placed at a fixed location for a certain period of time. But this approach may fail to detect the presence of fibers. For example, if sampling is conducted for a short time during a quiet period (i.e., when air movement is limited), many fibers will settle out of the air onto the floor and other surfaces and may not be captured on the filter. Under these conditions, air measurements could show little or no asbestos.

Previously, EPA recommended sampling for at least eight hours to cover various air circulation conditions and thus increase the likelihood of capturing asbestos fibers if they are present. A quicker and more effective way to accomplish this, however, is to circulate the air artificially so that the fibers remain airborne during sampling.

This "aggressive sampling" is recommended for the post-abatement air test. Recommended methods for conducting aggressive sampling are presented in Appendix M. They use forced-air equipment such as a leaf blower to dislodge free fibers, then slow-speed fans to keep the fibers suspended during sampling.

Persons who conduct the sampling should wear a respirator. Even though the work site has been cleaned and has passed the visual test, levels of airborne asbestos still may be elevated.

6.4.2.2 Analysis of Samples

Three microscopic methods are currently being used to analyze asbestos: phase contrast microscopy (PCM), scanning electron microscopy (SEM), and transmission electron microscopy (TEM). The characteristics and relative merits of each method are summarized in Table 5 and are described in detail in the companion EPA guidance document (USEPA 1985b).

As indicated in Table 5, PCM is the method that is most familiar, available, and frequently used. It is also the least expensive and has a well-established analytical protocol. (As noted in Section 4.1.2, OSHA specifies PCM for monitoring worker exposure in asbestos industries.) However, the NIOSH protocol for PCM does not distinguish between asbestos and other types of fibers and counts only fibers longer than 5 micrometers. Nor is PCM sensitive enough to detect the extremely thin fibers typical of airborne asbestos in buildings. Thus, the interpretation of PCM results assumes that a low concentration of relatively large airborne fibers means that the concentration of asbestos fibers is also low.

The TEM method gives the most complete information on airborne asbestos: it can distinguish asbestos from other fibers and also is able to detect very thin fibers. However, it can be expensive and time-consuming. TEM is not widely available.

TABLE 5. COMPARISON OF METHODS FOR MEASURING AIRBORNE ASBESTOS

	PCM	SEM	TEM
Standard Methods	NIOSH P&CAM 239 Method.[1]	No standard method.	EPA provisional method & update.[2]
Quality Assurance	Proficiency Analytical Testing Program; no NBS[3] reference materials.	No lab testing, or NBS reference materials.	Limited lab testing; NBS reference materials available.
Cost	$25-50	$50-300	$200-600
Availability	Most available.	Less available.	Least available.
Time Requirements	1 hr. preparation & analysis, < 6 hrs. turnaround.	4 hrs. preparation & analysis, 6-24 hrs. turnaround.	4-24 hrs. preparation & analysis, 2-7 days turnaround.
Sensitivity (Thinnest Fiber Visible)	0.15 μm at best; 0.25 μm typical.	0.05 μm at best; 0.20 μm typical.	0.0002 μm at best; 0.0025 μm typical.
Specificity	Not specific for asbestos.	More specific than PCM but not definitive for asbestos.	Definitive for asbestos. when used to its fullest capabilities.

[1] NIOSH 1979. The new NIOSH 7400 method is an alternative.
[2] USEPA 1977, Yamate 1984.
[3] National Bureau of Standards.

Source: Taken with modification from USEPA 1985b.

The SEM method can be somewhat more specific for asbestos and more sensitive to thin fibers than PCM, but less so than TEM. It is also less expensive and time-consuming than TEM. At present, however, no standard measurement protocol is available for SEM. As a result, it has not been systematically evaluated nor has the reliability of SEM measurements been established.

EPA acknowledges that all three methods are used in air testing for the purpose of releasing abatement contractors. However, only PCM and TEM have standard methods and testing programs. A standard method has not yet been developed for SEM. While TEM is technically the method of choice, PCM is the only option in many localities.

6.4.2.3 Recommended Test Specifications

Regardless of the microscopic method for measuring asbestos, identifying homogeneous work sites is the first important step in the process. A site within the abatement work area is homogeneous if it contains one type of ACM and only one type of abatement was used. For sampling purposes, the air in each

homogeneous site is assumed to be relatively uniform. Guidelines for locating the samplers are included in Appendix M. Several other aspects of the air test are identical, regardless of microscopic method:

- Choose sampling locations within the homogeneous work site to assure representative samples. (See Appendix M).
- Begin sampling when the work site is dry (24 hours after cleaning).
- Conduct aggressive air sampling in all cases.
- Follow sampling and analysis specifications, including procedures for quality control.

The asbestos program manager should be sure the technical advisor in charge of the air test knows the specifications listed below. The advisor should insist that recommended procedures be followed for both air sampling and laboratory analysis.

Testing with the TEM Method

Sampling:

- Draw at least 3000 liters of air through each filter at a rate of 2 to 12 liters per minute.
- Collect at least five samples in each homogeneous work site.
- At the same time, collect at least five samples just outside the work site but within the building. These samples will be compared with those collected inside the work site to ensure that the work site is at least as clean as the incoming air (see Appendix M for details).[1]

Analysis:

- Measure the asbestos on each filter with TEM using the EPA provisional procedures and updates (USEPA 1977 and Yamate 1984).
- Use a direct transfer method of sample preparation if possible (see Appendix M).
- Express the results as f/cc, or as ng/m^3 if an indirect sample preparation is used.
- Include at least one field blank [2] and one laboratory blank per abatement job for quality control purposes (see Section 6.4.3). Also, split one work site sample and conduct duplicate analyses.

Release Criterion:

- Release the contractor if the average fiber concentration of the work site samples is not statistically larger than the average of the outside samples. Each homogeneous site must pass the test before the contractor is released. (Appendix M contains information to determine statistical differences.)
- If the average of the work site samples is statistically larger than the average of the outside samples, clean the entire work site again and repeat the test (collect new work site samples and follow the procedures described above).

[1] If a negative pressure system has not been used, collect the "outside" samples outdoors.

[2] A blank is a filter that is not used for sampling but is otherwise treated in the same way as other filters.

Testing with the PCM Method

Sampling:

- Draw at least 3000 liters of air through each filter at a rate of 2 to 12 liters per minute.
- Collect at least five samples per homogeneous work site, or one per room, whichever is greater.

Analysis:

- Measure the asbestos on each filter with PCM using the NIOSH P&CAM 239 procedures. (The newer NIOSH 7400 procedures can also be used. See Appendix M.)
- Include at least one field blank and one laboratory blank per abatement project, for quality control purposes. Also, split one work site sample for duplicate analysis.

Release Criterion:

- Release the contractor if every sample value is below the limit of reliable quantification (approximately 0.01 f/cc when 3000 liters of air are sampled; see Appendix M).
- If any of the sample values is above the prescribed level, clean the entire work site again, collect new samples, and evaluate the samples as described above.

For each method, the recommended number of samples and the prescribed use of the data defining the release criteria are based on a compromise involving practical considerations of cost, time required for the tests, performance characteristics of the methods, and statistical criteria. Details of the sampling and analysis specifications are provided in Appendix M.

6.4.3 Quality Assurance

Notwithstanding the advantages of one microscopic method over another, no method will produce reliable results unless both the field sampling and laborabory analysis are properly conducted. To obtain reliable results, a quality assurance (QA) program for the collection and analysis of data is essential.

The objective is to produce measurements with sufficient and documented quality for their intended purpose. In this case, the purpose is to determine satisfactory completion of an abatement project. The components of a QA program range from clerical activities such as labeling samples and documenting results, to performing technically complex tasks in the laboratory. When establishing the quality of data, however, all activities are equally important.

Preparing and implementing a QA program requires the assistance of a technical advisor on asbestos measurement. EPA and OSHA have published guidelines on quality assurance for TEM and PCM (Yamate 1984, and NIOSH 1979). The QA Program Checklist below can be used by the asbestos program manager in reviewing a proposed QA program.

QA Program Checklist

- **Training and Experience:** Be sure that all persons producing the measurement understand their roles and are trained. Select a laboratory with demonstrated proficiency in asbestos analysis. Request details of the laboratory's quality control program, and get documentation of the lowest level of fibers routinely reported.

- **Quality Control Checks:** Use field and laboratory blanks to check for fiber contamination, coded sample labels to avoid analyst bias, duplicate analyses to confirm precision, and a second laboratory to spot-check the accuracy of results.

- **Chain-of-Custody:** Assign responsibility for security of the samples to specific persons at each stage of the analysis. Document each step in the passage of the sample from the field to the laboratory.

- **Documentation:** Check and document laboratory results as well as their labeling. The building owner should retain all test results and records documenting the testing process.

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Appendix A. Asbestos-Containing Materials Found in Buildings*

Subdivision	Generic name	Asbestos (%)	Dates of use	Binder/sizing
Surfacing material	sprayed- or troweled-on	1-95	1935-1970	sodium silicate, portland cement, organic binders.
Preformed thermal insulating products	batts, blocks, and pipe covering			
	85% magnesia	15	1926-1949	magnesium carbonate
	calcium silicate	6-8	1949-1971	calcium silicate
Textiles	cloth[a]			
	blankets (fire)[a]	100	1910-present	none
	felts	90-95	1920-present	cotton/wool
	blue stripe	80	1920-present	cotton
	red stripe	90	1920-present	cotton
	green stripe	95	1920-present	cotton
	sheets	50-95	1920-present	cotton/wool
	cord/rope/yarn[a]	80-100	1920-present	cotton/wool
	tubing	80-85	1920-present	cotton/wool
	tape/strip	90	1920-present	cotton/wool
	curtains[a]			
	(theatre, welding)	60-65	1945-present	cotton
Cementitious concrete-like products	extrusion panels	8	1965-1977	portland cement
	corrugated	20-45	1930-present	portland cement
	flat	40-50	1930-present	portland cement
	flexible	30-50	1930-present	portland cement
	flexible perforated	30-50	1930-present	portland cement
	laminated (outer surface)	35-50	1930-present	portland cement
	roof tiles	20-30	1930-present	portland cement
	clapboard and shingles,			
	clapboard	12-15	1944-1945	portland cement
	siding shingles	12-14	unknown-present	portland cement
	roofing shingles	20-32	unknown-present	portland cement
	pipe	20-15	1935-present	portland cement
Paper products	corrugated			
	high temperature	90	1935-present	sodium silicate
	moderate temperature	35-70	1910-present	starch
	indented	98	1935-present	cotton and organic binder
	millboard	80-85	1925-present	starch, lime, clay
Roofing felts	smooth surface	10-15	1910-present	asphalt
	mineral surface	10-15	1910-present	asphalt
	shingles	1	1971-1974	asphalt
	pipeline	10	1920-present	asphalt

* The information in this Appendix is taken, with modification, from: Lory EE, Coin DC. February 1981. *Management Procedure for Assessment of Friable Asbestos Insulating Material*. Port Hueneme, CA: Civil Engineering Laboratory Naval Construction Battalion Center. The U.S. Navy prohibits the use of asbestos-containing materials when acceptable nonasbestos substitutes have been identified.

[a] Laboratory aprons, gloves, cord, rope, fire blankets, and curtains may be common in schools.

Appendix A. (continued)

Subdivision	Generic name	Asbestos (%)	Dates of use	Binder/sizing
Asbestos-containing compounds	caulking putties	30	1930-present	linseed oil
	adhesive (cold applied)	5-25	1945-present	asphalt
	joint compound		1945-1975	asphalt
	roofing asphalt	5	unknown-present	asphalt
	mastics	5-25	1920-present	asphalt
	asphalt tile cement	13-25	1959-present	asphalt
	roof putty	10-25	unknown-present	asphalt
	plaster/stucco	2-10	unknown-present	portland cement
	spackles	3-5	1930-1975	starch, casein, synthetic resins
	sealants fire/water	50-55	1935-present	caster oil or polyisobutylene
	cement, insulation	20-100	1900-1973	clay
	cement, finishing	55	1920-1973	clay
	cement, magnesia	15	1926-1950	magnesium carbonate
Asbestos ebony products		50	1930-present	portland cement
Flooring tile and Sheet Goods	vinyl/asbestos tile	21	1950-present	poly(vinyl)chloride
	asphalt/asbestos tile	26-33	1920-present	asphalt
	sheet goods/resilient	30	1950-present	dry oils
Wallcovering	vinyl wallpaper	6-8	unknown-present	—
Paints and coatings	roof coating	4-7	1900-present	asphalt
	air tight	15	1940-present	asphalt

asbestos measured in air samples indicate that, on an average, about 30 fibers counted by the NIOSH procedures equal one nanogram of asbestos. This relationship applies to samples collected during the spray application of asbestos insulation. For these samples, each fiber counted weighs an average of 0.033 ng, or about 37 times more than those in the example, and 2,000,000 of them would weigh about 67,000 ng.

asbestos on a dry weight basis on equipment and machinery, except as provided in paragraph (c) of this section:

(1) Notify the Administrator at least 20 days before beginning the spraying operation. Include the following information in the notice:

(i) Name and address of owner or operator.

(ii) Location of spraying operation.

(iii) Procedures to be followed to meet the requirements of this paragraph.

(2) Discharge no visible emissions to the outside air from the spray-on application of the asbestos-containing material or use the methods specified by § 61.154 to clean emissions containing particulate asbestos material before they escape to, or are vented to, the outside air.

(c) The requirements of paragraphs (a) and (b) of this section do not apply to the spray-on application of materials where the asbestos fibers in the materials are encapsulated with a bituminous or resinous binder during spraying and the materials are not friable after drying.

(d) Owners and operators of sources subject to this section are exempt from the requirements of §§ 61.05(a), 61.07, and 61.09.

(Approved by the Office of Management and Budget under control number 2060-0284.)

§ 61.149 Standard for fabricating.

(a) *Applicability.* This section applies to the following fabricating operations using commercial asbestos:

(1) The fabrication of cement building products.

(2) The fabrication of friction products, except those operations that primarily install asbestos friction materials on motor vehicles.

(3) The fabrication of cement or silicate board for ventilation hoods; ovens; electrical panels; laboratory furniture, bulkheads, partitions, and ceilings for marine construction; and flow control devices for the molten metal industry.

(b) *Standard.* Each owner or operator of any of the fabricating operations to which this section applies shall either:

(1) Discharge no visible emissions to the outside air from any of the operations or from any building or structure in which they are conducted; or

(2) Use the methods specified by § 61.154 to clean emissions containing particulate asbestos material before they escape to, or are vented to, the outside air.

§ 61.150 Standard for insulating materials.

After the effective date of this regulation, no owner or operator of a facility may install or reinstall on a facility component any insulating materials that contain commercial asbestos if the materials are either molded and friable or wet-applied and friable after drying. The provisions of this paragraph do not apply to spray-applied insulating materials regulated under § 61.148.

§ 61.151 Standard for waste disposal for asbestos mills.

Each owner or operator of any source covered under the provisions of § 61.142 shall:

(a) Deposit all asbestos-containing waste material at waste disposal sites operated in accordance with the provisions of § 61.156; and

(b) Discharge no visible emissions to the outside air from the transfer of asbestos waste from control devices to the tailings conveyor, or use the methods specified by § 61.154 to clean emissions containing particulate asbestos material before they escape to, or are vented to, the outside air. Dispose of the asbestos waste from control devices in accordance with § 61.152(b) or paragraph (c) of this section; and

(c) Discharge no visible emissions to the outside air during the collection, processing, packaging, transporting, or deposition of any asbestos-containing waste material, or use one of the disposal methods specified in paragraphs (c) (1) or (2) of this section, as follows:

(1) Use a wetting agent as follows:

(i) Adequately mix all asbestos-containing waste material with a wetting agent recommended by the manufacturer of the agent to effectively wet dust and tailings, before depositing the material at a waste disposal site. Use the agent as recommended for the

the area adequate to prevent exposure of the asbestos-containing waste material; or

(3) Cover the asbestos-containing waste material with at least 60 centimeters (2 feet) of compacted nonasbestos-containing material, and maintain it to prevent exposure of the asbestos-containing waste; or

(4) For inactive waste disposal sites for asbestos tailings, apply a resinous or petroleum-based dust suppression agent that effectively binds dust and controls wind erosion. Use the agent as recommended for the particular asbestos tailings by the manufacturer of the dust suppression agent. Obtain prior approval of the Administrator to use other equally effective dust suppression agents. For purposes of this paragraph, waste crankcase oil is not considered a dust suppression agent.

(b) Unless a natural barrier adequately deters access by the general public, install and maintain warning signs and fencing as follows, or comply with paragraph (a)(2) or (a)(3) of this section.

(1) Display warning signs at all entrances and at intervals of 100 m (330 feet) or less along the property line of the site or along the perimeter of the sections of the site where asbestos-containing waste material was deposited. The warning signs must:

(i) Be posted in such a manner and location that a person can easily read the legend; and

(ii) Conform to the requirements for 51 cm×36 cm (20"×14") upright format signs specified in 29 CFR 1910.145(d)(4) and this paragraph; and

(iii) Display the following legend in the lower panel with letter sizes and styles of a visibility at least equal to those specified in this paragraph.

Legend	Notation
Asbestos Waste Disposal Site	2.5 cm (1 inch) Sans Serif, Gothic or Block
Do Not Create Dust	1.9 cm (¾ inch) Sans Serif, Gothic or Block
Breathing Asbestos is Hazardous to Your Health	14 Point Gothic

Spacing between any two lines must be at least equal to the height of the upper of the two lines.

(2) Fence the perimeter of the site in a manner adequate to deter access by the general public.

(3) Upon request and supply of appropriate information, the Administrator will determine whether a fence or a natural barrier adequately deters access by the general public.

(c) The owner or operator may use an alternative control method that has received prior approval of the Administrator rather than comply with the requirements of paragraph (a) or (b) of this section.

§ 61.154 Air-cleaning.

(a) The owner or operator who elects to use air-cleaning, as permitted by §§ 61.142, 61.144, 61.147(c)(2), 61.147(d)(2), 61.148(b)(2), 61.149(b), 61.151(b), 61.151(c)(1)(ii), 61.152(b)(1)(ii), and 61.152(b)(2) shall:

(1) Use fabric filter collection devices, except as noted in paragraph (b) of this section, doing all of the following:

(i) Operating the fabric filter collection devices at a pressure drop of no more than .995 kilopascal (4 inches water gage), as measured across the filter fabric; and

(ii) Ensuring that the airflow permeability, as determined by ASTM Method D737-75, does not exceed 9 $m^3/min/m^2$ (30 $ft^3/min/ft^2$) for woven fabrics or $11^3/min/m^2$(35 $ft^3/min/ft^2$) for felted fabrics, except that 12 $m^3/min/m^2$ (40 ft^3min/ft^2) for woven and 14 $m^3/mih/m^2$ (45 ft $^3min/ft^2$) for felted fabrics is allowed for filtering air from asbestos ore dryers; and

(iii) Ensuring that felted fabric weighs at least 475 grams per square meter (14 ounces per square yard) and is at least 1.6 millimeters (one-sixteenth inch) thick throughout; and

(iv) Avoiding the use of synthetic fabrics that contain fill yarn other than that which is spun.

(2) Properly install, use, operate, and maintain all air-cleaning equipment authorized by this section. Bypass devices may be used only during upset or emergency conditions and then only for so long as it takes to shut down the operation generating the particulate asbestos material.

(b) There are the following exceptions to paragraph (a)(1):

(1) If the use of fabric creates a fire or explosion hazard, the Administrator may authorize as a substitute the use of wet collectors designed to operate with a unit contacting energy of at least 9.95 kilopascals (40 inches water gage pressure).

(2) The Administrator may authorize the use of filtering equipment other than that described in paragraphs (a)(1) and (b)(1) of this section if the owner or operator demonstrates to the Administrator's satisfaction that it is equivalent to the described equipment in filtering particulate asbestos material.

[49 FR 13661, Apr. 5, 1984; 49 FR 25453, June 21, 1984]

§ 61.155 Reporting.

(a) Within 90 days after the effective date of this subpart, each owner or operator of any existing source to which this subpart applies shall provide the following information to the Administrator, except that any owner or operator who provided this information prior to April 5, 1984 in order to comply with § 61.24 (which this section replaces) is not required to resubmit it.

(1) A description of the emission control equipment used for each process; and

(2) If a fabric filter device is used to control emissions, the pressure drop across the fabric filter in inches water gage; and

(i) If the fabric device uses a woven fabric, the airflow permeability in $m^3/min/m^2$ and; if the fabric is synthetic, whether the fill yarn is spun or not spun; and

(ii) If the fabric filter device uses a felted fabric, the density in g/m^2, the minimum thickness in inches, and the airflow permeability in $m^3/min/m^2$.

(3) For sources subject to §§ 61.151 and 61.152:

(i) A brief description of each process that generates asbestos-containing waste material; and

(ii) The average weight of asbestos-containing waste material disposed of, measured in kg/day; and

(iii) The emission control methods used in all stages of water disposal; and

(iv) The type of disposal site or incineration site used for ultimate disposal, the name of the site operator, and the name and location of the disposal site.

(4) For sources subject to § 61.153:

(i) A brief description of the site; and

(ii) The method or methods used to comply with the standard, or alternative procedures to be used.

(b) The information required by paragraph (a) of this section must accompany the information required by § 61.10. The information described in this section must be reported using the format of Appendix A of this part.

(Approved by this Office of Management and Budget under control number 2000-0264)

(Sec. 114, Clean Air Act as amended (42 U.S.C. 7414))

§ 61.156 Active waste disposal sites.

To be an acceptable site for disposal of asbestos-containing waste material under §§ 61.151 and 61.152, an active waste disposal site must meet the requirements of this section.

(a) Either there must be no visible emissions to the outside air from any active waste disposal site where asbestos-containing waste material has been deposited, or the requirements of paragraph (c) or (d) of this section must be met.

(b) Unless a natural barrier adequately deters access by the general public, either warning signs and fencing must be installed and maintained as follows, or the requirements of paragraph (c)(1) of this section must be met.

(1) Warning signs must be displayed at all entrances and at intervals of 100 m (330 ft) or less along the property line of the site or along the perimeter of the sections of the site where asbestos-containing waste material is deposited. The warning signs must:

(i) Be posted in such a manner and location that a person can easily read the legend; and

(ii) Conform to the requirements of 51 cm × 36 cm (20" × 14") upright

format signs specified in 29 CFR 1910.145(d)(4) and this paragraph; and

(iii) Display the following legend in the lower panel with letter sizes and styles of a visibility at least equal to those specified in this paragraph.

Legend	Notation
Asbestos Waste Disposal Site.	2.5 cm (1 inch) Sans Serif, Gothic or Block.
Do Not Create Dust	1.9 cm (¾ inch) Sans Serif, Gothic or Block.
Breathing Asbestos is Hazardous to Your Health.	14 Point Gothic.

Spacing between any two lines must be at least equal to the height of the upper of the two lines.

(2) The perimeter of the disposal site must be fenced in a manner adequate to deter access by the general public.

(3) Upon request and supply of appropriate information, the Administrator will determine whether a fence or a natural barrier adequately deters access by the general public.

(c) Rather than meet the no visible emission requirement of paragraph (a) of this section, an active waste disposal site would be an acceptable site if at the end of each operating day, or at least once every 24-hour period while the site is in continuous operation, the asbestos-containing waste material which was deposited at the site during the operating day or previous 24-hour period is covered with either.

(1) At least 15 centimeters (6 inches) of compacted nonasbestos-containing material, or

(2) A resinous or petroleum-based dust suppression agent that effectively binds dust and controls wind erosion. This agent must be used as recommended for the particular dust by the manufacturer of the dust suppression agent. Other equally effective dust suppression agents may be used upon prior approval by the Administrator. For purposes of this paragraph, waste crankcase oil is not considered a dust suppression agent.

(d) Rather than meet the no visible emission requirement of paragraph (a) of this section, an active waste disposal site would be an acceptable site if an alternative control method for emissions that has received prior approval by the Administrator is used.

(Secs. 112 and 301(a) of the Clean Air Act as amended (42 U.S.C. 7412, 7601(a))

Appendix D. Addresses of EPA NESHAPS Contacts and Regional Asbestos Coordinators

NESHAPs Contacts

(For information on NESHAPs rule compliance and disposal)

Region 1
Asbestos NESHAPs Contact
Air Management Division
USEPA
JFK Federal Building
Boston, MA 02203
(617) 223-4872

Region 2
Asbestos NESHAPs Contact
Air & Waste Management Division
USEPA
26 Federal Plaza
New York, NY 10007
(212) 264-4479

Region 3
Asbestos NESHAPs Contact
Air Management Division
USEPA
841 Chestnut Street
Philadelphia, PA 19107
(215) 597-6552

Region 4
Asbestos NESHAPs Contact
Air, Pesticide & Toxic Management
USEPA
345 Courtland Street N.E.
Atlanta, GA 30365
(404) 881-4901

Region 5
Asbestos NESHAPs Contact
Air Management Division
USEPA
230 S. Dearborn Street
Chicago, IL 60604
(312) 353-2088

Region 6
Asbestos NESHAPs Contact
Air & Waste Management Division
USEPA
1201 Elm Street
Dallas, TX 75270
(214) 767-9835

Region 7
Asbestos NESHAPs Contact
Air & Waste Management Division
USEPA
726 Minnesota Avenue
Kansas City, KS 66101
(913) 236-2576

Region 8
Asbestos NESHAPs Contact
Air & Waste Management Division
USEPA
1860 Lincoln Street
Denver, CO 80295
(303) 293-1767

Region 9
Asbestos NESHAPs Contact
Air Management Division
USEPA
215 Fremont Street
San Francisco, CA 94105
(415) 974-7648

Region 10
Asbestos NESHAPs Contact
Air & Toxics Management Division
USEPA
1200 Sixth Avenue
Seattle, WA 98101
(206) 442-2724

Regional Asbestos Coordinators

(For information on asbestos identification, health effects, abatement options, analytic techniques, asbestos in schools, and contract documents)

Region 1
Regional Asbestos Coordinator
USEPA
JFK Federal Building
Boston, MA 02203
(617) 223-0585

Region 2
Regional Asbestos Coordinator
USEPA
Woodbridge Avenue
Edison, NJ 08837
(201) 321-6668

Region 3
Regional Asbestos Coordinator
USEPA
841 Chestnut Street
Philadelphia, PA 19107
(215) 597-9859

Region 4
Regional Asbestos Coordinator
USEPA
345 Courtland Street N.E.
Atlanta, GA 30365
(404) 881-3864

Region 5
Regional Asbestos Coordinator
USEPA
230 S. Dearborn Street
Chicago, IL 60604
(312) 886-6879

Region 6
Regional Asbestos Coordinator
USEPA
First International Building
1201 Elm Street
Dallas, TX 75270
(214) 767-5314

Region 7
Regional Asbestos Coordinator
USEPA
726 Minnesota Avenue
Kansas City, KS 66101
(913) 236-2838

Region 8
Regional Asbestos Coordinator
USEPA
999 18th Street
Denver, CO 80202
(303) 293-1730

Region 9
Regional Asbestos Coordinator
USEPA
215 Fremont Street
San Francisco, CA 94105
(415) 974-8588

Region 10
Regional Asbestos Coordinator
USEPA
1200 Sixth Avenue
Seattle, WA 98101
(206) 442-2632

Appendix E. Phone Numbers for Obtaining Information and EPA Publications

Information — **800/334-8571**

- Sampling and analysis of ACM (bulk materials)
- EPA Sealant Study

Publications — **800/424-9065 (554-1404 — In Washington, DC)**

- Friable Asbestos-Containing Materials in Schools: Identification and Notification Rule (40 CFR Part 763).
- Evaluation of the EPA Asbestos-in-Schools Identification and Notification Rule. EPA 560/5-84-005.
- Asbestos in Buildings: National Survey of Asbestos-Containing Friable Materials. EPA 560/5-84-006.
- Asbestos in Buildings: Guidance for Service and Maintenance Personnel. EPA 560/5-85-018.
- Asbestos Waste Management Guidance. EPA 530-SW-85-007.
- Asbestos Fact Book. EPA Office of Public Affairs.

Appendix F. Occupational Health and Safety (OSHA) Asbestos Regulations (29 CFR 1910.1001)

§ 1910.1001 Asbestos.

(a) *Definitions.* For the purpose of this section, (1) "Asbestos" includes chrysotile, amosite, crocidolite, tremolite, anthophyllite, and actinolite.

(2) "Asbestos fibers" means asbestos fibers longer than 5 micrometers.

(b) *Permissible exposure to airborne concentrations of asbestos fibers*—(1) *Standard effective July 7, 1972.* The 8-hour time-weighted average airborne concentrations of asbestos fibers to which any employee may be exposed shall not exceed five fibers, longer than 5 micrometers, per cubic centimeter of air, as determined by the method prescribed in paragraph (e) of this section.

(2) *Standard effective July 1, 1976.* The 8-hour time-weighted average airborne concentrations of asbestos fibers to which any employee may be exposed shall not exceed two fibers, longer than 5 micrometers, per cubic centimeter of air, as determined by the method prescribed in paragraph (e) of this section.

(3) *Ceiling concentration.* No employee shall be exposed at any time to airborne concentrations of asbestos fibers in excess of 10 fibers, longer than 5 micrometers, per cubic centimeter of air, as determined by the method prescribed in paragraph (e) of this section.

(c) *Methods of compliance*—(1) *Engineering methods.* (i) *Engineering controls.* Engineering controls, such as, but not limited to, isolation, enclosure, exhaust ventilation, and dust collection, shall be used to meet the exposure limits prescribed in paragraph (b) of this section.

(ii) *Local exhaust ventilation.* (a) Local exhaust ventilation and dust collection systems shall be designed, constructed, installed, and maintained in accordance with the American National Standard Fundamentals Governing the Design and Operation of Local Exhaust Systems, ANSI Z9.2-1971, which is incorporated by reference herein.

(b) See § 1910.6 concerning the availability of ANSI Z9.2-1971, and the maintenance of a historic file in connection therewith. The address of the American National Standards Institute is given in § 1910.100.

(iii) *Particular tools.* All hand-operated and power-operated tools which may produce or release asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section, such as, but not limited to, saws, scorers, abrasive wheels, and drills, shall be provided with local exhaust ventilation systems in accordance with subdivision (ii) of this subparagraph.

(2) *Work practices*—(i) *Wet methods.* Insofar as practicable, asbestos shall be handled, mixed, applied, removed, cut, scored, or otherwise worked in a wet state sufficient to prevent the emission of airborne fibers in excess of the exposure limits prescribed in paragraph (b) of this section, unless the usefulness of the product would be diminished thereby.

(ii) *Particular products and operations.* No asbestos cement, mortar, coating, grout, plaster, or similar material containing asbestos shall be removed from bags, cartons, or other containers in which they are shipped, without being either wetted, or enclosed, or ventilated so as to prevent effectively the release of airborne asbestos fibers in excess of the limits prescribed in paragraph (b) of this section.

(iii) *Spraying, demolition, or removal.* Employees engaged in the spraying of asbestos, the removal, or demolition of pipes, structures, or equipment covered or insulated with asbestos, and in the removal or demolition of asbestos insulation or coverings shall be provided with respiratory equipment in accordance with paragraph (d)(2)(iii) of this section and with special clothing in accordance with paragraph (d)(3) of this section.

(d) *Personal protective equipment*—(1) Compliance with the exposure limits prescribed by paragraph (b) of this section may not be achieved by the use of respirators or shift rotation of employees, except:

(i) During the time period necessary to install the engineering controls and to institute the work practices required by paragraph (c) of this section;

(ii) In work situations in which the methods prescribed in paragraph (c) of this section are either technically not feasible or feasible to an extent insufficient to reduce the airborne concentrations of asbestos fibers below the limits prescribed by paragraph (b) of this section; or

(iii) In emergencies.

(iv) Where both respirators and personnel rotation are allowed by paragraphs (d)(1) (i), (ii), or (iii) of this section, and both are practicable, personnel rotation shall be preferred and used.

(2) Where a respirator is permitted by paragraph (d)(1) of this section, it shall be selected from among those approved by the Bureau of Mines, Department of the Interior, or the National Institute for Occupational Safety and Health, Department of

Health, Education, and Welfare, under the provisions of 30 CFR Part 11 (37 FR 6244, Mar. 25, 1972), and shall be used in accordance with subdivisions (i), (ii), (iii), and (iv) of this subparagraph.

(I) *Air purifying respirators.* A reusable or single use air purifying respirator, or a respirator described in paragraph (d)(2) (ii) or (iii) of this section, shall be used to reduce the concentrations of airborne asbestos fibers in the respirator below the exposure limits prescribed in paragraph (b) of this section, when the ceiling or the 8-hour time-weighted average airborne concentrations of asbestos fibers are reasonably expected to exceed no more than 10 times those limits.

(II) *Powered air purifying respirators.* A full facepiece powered air purifying respirator, or a powered air purifying respirator, or a respirator described in paragraph (d)(2)(iii) of this section, shall be used to reduce the concentrations of airborne asbestos fibers in the respirator below the exposure limits prescribed in paragraph (b) of this section, when the ceiling or the 8-hour time-weighted average concentrations of asbestos fibers are reasonably expected to exceed 10 times, but not 100 times, those limits.

(III) *Type "C" supplied-air respirators, continuous flow or pressure-demand class.* A type "C" continuous flow or pressure-demand, supplied-air respirator shall be used to reduce the concentrations of airborne asbestos fibers in the respirator below the exposure limits prescribed in paragraph (b) of this section, when the ceiling or the 8-hour time-weighted average airborne concentrations of asbestos fibers are reasonably expected to exceed 100 times those limits.

(iv) *Establishment of a respirator program.* (a) The employer shall establish a respirator program in accordance with the requirements of the American National Standards Practices for Respiratory Protection, ANSI Z88.2-1969, which is incorporated by reference herein.

(b) See § 1910.6 concerning the availability of ANSI Z88.2-1969 and the maintenance of a historic file in connection therewith. The address of the American National Standards Institute is given in § 1910.100.

(c) No employee shall be assigned to tasks requiring the use of respirators if, based upon his most recent examination, an examining physician determines that the employee will be unable to function normally wearing a respirator, or that the safety or health of the employee or other employees will be impaired by his use of a respirator. Such employee shall be rotated to another job or given the opportunity to transfer to a different position whose duties he is able to perform with the same employer, in the same geographical area and with the same seniority, status, and rate of pay he had just prior to such transfer, if such a different position is available.

(3) Special clothing: The employer shall provide, and require the use of, special clothing, such as coveralls or similar whole body clothing, head coverings, gloves, and foot coverings for any employee exposed to airborne concentrations of asbestos fibers, which exceed the ceiling level prescribed in paragraph (b) of this section.

(4) Change rooms: (i) At any fixed place of employment exposed to airborne concentrations of asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section, the employer shall provide change rooms for employees working regularly at the place.

(ii) Clothes lockers: The employer shall provide two separate lockers or containers for each employee, so separated or isolated as to prevent contamination of the employee's street clothes from his work clothes.

(iii) Laundering: (a) Laundering of asbestos contaminated clothing shall be done so as to prevent the release of air-borne asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section.

(b) Any employer who gives asbestos-contaminated clothing to another person for laundering shall inform such person of the requirement in paragraph (d)(4)(iii)(a) of this section to effectively prevent the release of airborne asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section.

(c) Contaminated clothing shall be transported in sealed impermeable bags, or other closed, impermeable containers, and labeled in accordance with paragraph (g) of this section.

(e) *Method of measurement.* All determinations of airborne concentrations of asbestos fibers shall be made by the membrane filter method at 400–450 × (magnification) (4 millimeter objective) with phase contrast illumination.

(f) *Monitoring*—(1) *Initial determinations.* Within 6 months of the publication of this section, every employer shall cause every place of employment where asbestos fibers are released to be monitored in such a way as to determine whether every employee's exposure to asbestos fibers is below the limits prescribed in paragraph (b) of this section. If the limits are exceeded, the employer shall immediately undertake a compliance program in accordance with paragraph (c) of this section.

(2) *Personal monitoring*—(i) Samples shall be collected from within the breathing zone of the employees, on membrane filters of 0.8 micrometer porosity mounted in an open-face filter holder. Samples shall be taken for the determination of the 8-hour time-weighted average airborne concentrations and of the ceiling concentrations of asbestos fibers.

(ii) Sampling frequency and patterns. After the initial determinations required by paragraph (f)(1) of this section, samples shall be of such frequency and pattern as to represent with reasonable accuracy the levels of exposure of employees. In no case shall the sampling be done at intervals greater than 6 months for employees whose exposure to asbestos may reasonably be foreseen to exceed the limits prescribed by paragraph (b) of this section.

(3) *Environmental monitoring.* (i) Samples shall be collected from areas of a work environment which are representative of the airborne concentrations of asbestos fibers which may reach the breathing zone of employees. Samples shall be collected on a membrane filter of 0.8 micrometer porosity mounted in an open-face filter holder. Samples shall be taken for the determination of the 8-hour time-weighted average airborne concentrations and of the ceiling concentrations of asbestos fibers.

(ii) *Sampling frequency and patterns.* After the initial determinations required by paragraph (f)(1) of this section, samples shall be of such frequency and pattern as to represent with reasonable accuracy the levels of exposure of the employees. In no case shall sampling be at intervals greater than 6 months for employees whose exposures to asbestos may reasonably be foreseen to exceed the exposure limits prescribed in paragraph (b) of this section.

(4) *Employee observation of monitoring.* Affected employees, or their representatives, shall be given a reasonable opportunity to observe any monitoring required by this paragraph and shall have access to the records thereof.

(g) *Caution signs and labels*—(1) *Caution signs*—(i) *Posting.* Caution signs shall be provided and displayed at each location where airborne concentrations of asbestos fibers may be in excess of the exposure limits prescribed in paragraph (b) of this section. Signs shall be posted at such a distance from such a location so that an employee may read the signs and take necessary protective steps before entering the area marked by the signs. Signs shall be posted at all approaches to areas containing excessive concentrations of airborne asbestos fibers.

(ii) *Sign specifications.* The warning signs required by paragraph (g)(1)(i) of this section shall conform to the requirements of 20" × 14" vertical format signs specified in § 1910.145(d)(4), and to this subdivision. The signs shall display the following legend in the lower panel, with letter sizes and styles of a visibility at least equal to that specified in this subdivision.

Legend	Notation
Asbestos	1" Sans Serif, Gothic or Block.
Dust Hazard	1" Sans Serif, Gothic or Block.
Avoid Breathing Dust	½" Gothic.
Wear Assigned Protective Equipment.	½" Gothic.

Legend	Notation
Do Not Remain In Area Unless Your Work Requires It. Breathing Asbestos Dust May Be Hazardous To Your Health.	¼" Gothic. 14 point Gothic.

Spacing between lines shall be at least equal to the height of the upper of any two lines.

(2) *Caution labels*—(i) *Labeling.* Caution labels shall be affixed to all raw materials, mixtures, scrap, waste, debris, and other products containing asbestos fibers, or to their containers, except that no label is required where asbestos fibers have been modified by a bonding agent, coating, binder, or other material so that during any reasonably foreseeable use, handling, storage, disposal, processing, or transportation, no airborne concentrations of asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section will be released.

(ii) *Label specifications.* The caution labels required by paragraph (g)(2)(i) of this section shall be printed in letters of sufficient size and contrast as to be readily visible and legible. The label shall state:

CAUTION

Contains Asbestos Fibers

Avoid Creating Dust

Breathing Asbestos Dust May Cause Serious Bodily Harm

(h) *Housekeeping*—(1) *Cleaning.* All external surfaces in any place of employment shall be maintained free of accumulations of asbestos fibers if, with their dispersion, there would be an excessive concentration.

(2) *Waste disposal.* Asbestos waste, scrap, debris, bags, containers, equipment, and asbestos-contaminated clothing, consigned for disposal, which may produce in any reasonably foreseeable use, handling, storage, processing, disposal, or transportation airborne concentrations of asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section shall be collected and disposed of in sealed impermeable bags, or other closed, impermeable containers.

(i) *Recordkeeping*—(1) *Exposure records.* Every employer shall maintain records of any personal or environmental monitoring required by this section. Records shall be maintained for a period of at least 20 years and shall be made available upon request to the Assistant Secretary of Labor for Occupational Safety and Health, the Director of the National Institute for Occupational Safety and Health, and to authorized representatives of either.

(2) *Access.* Employee exposure records required by this paragraph shall be provided upon request to employees, designated representatives, and the Assistant Secretary in accordance with 29 CFR 1910.20 (a)–(e) and (g)–(i).

(3) *Employee notification.* Any employee found to have been exposed at any time to airborne concentrations of asbestos fibers in excess of the limits prescribed in paragraph (b) of this section shall be notified in writing of the exposure as soon as practicable but not later than 5 days of the finding. The employee shall also be timely notified of the corrective action being taken.

(j) *Medical examinations*—(1) *General.* The employer shall provide or make available at his cost, medical examinations relative to exposure to asbestos required by this paragraph.

(2) *Preplacement.* The employer shall provide or make available to each of his employees, within 30 calendar days following his first employment in an occupation exposed to airborne concentrations of asbestos fibers, a comprehensive medical examination, which shall include, as a minimum, a chest roentgenogram (posterior-anterior 14 × 17 inches), a history to elicit symptomatology of respiratory disease, and pulmonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second ($FEV_{1.0}$).

(3) *Annual examinations.* On or before January 31, 1973, and at least annually thereafter, every employer shall provide, or make available, comprehensive medical examinations to each of his employees engaged in occupations exposed to airborne concentrations of asbestos fibers. Such annual examination shall include, as a minimum, a chest roentgenogram (posteri-

or-anterior 14 x 17 inches), a history to elicit symptomatology of respiratory disease, and pulmonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second ($FEV_{1.0}$).

(4) *Termination of employment.* The employer shall provide, or make available, within 30 calendar days before or after the termination of employment of any employee engaged in an occupation exposed to airborne concentrations of asbestos fibers, a comprehensive medical examination which shall include, as a minimum, a chest roentgenogram (posterior-anterior 14 x 17 inches), a history to elicit symptomatology of respiratory disease, and pulmonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second ($FEV_{1.0}$).

(5) *Recent examinations.* No medical examination is required of any employee, if adequate records show that the employee has been examined in accordance with this paragraph within the past 1-year period.

(6) *Medical records*—(i) *Maintenance.* Employers of employees examined pursuant to this paragraph shall cause to be maintained complete and accurate records of all such medical examinations. Records shall be retained by employers for at least 20 years.

(ii) *Access.* Records of the medical examinations required by this paragraph shall be provided upon request to employees, designated representatives, and the Assistant Secretary in accordance with 29 CFR 1910.20 (a)-(e) and (g)-(i). These records shall also be provided upon the request to the Director of NIOSH. Any physician who conducts a medical examination required by this paragraph shall furnish to the employer of the examined employee all the information specifically required by this paragraph, and any other medical information related to occupational exposure to asbestos fibers.

Appendix G. Specifications for Sampling Materials and Selecting a Qualified Laboratory to Analyze for Asbestos

G.1 Collecting Samples

Taking a sample of ACM can damage the material and cause significant release of fibers. The following guidelines are designed to minimize both damage and fiber release.[1]

- Wear at least a half-face respirator with disposable filters (see Section 5.1).
- Wet the surface of the material to be sampled with water from a spray bottle or place a plastic bag around the sampler.
- Sample with a reusable sampler such as a cork borer or a single-use sampler such as a glass vial. (Figure G-1 shows a single-use sampler constructed from an acrylic tube.)
- With a twisting motion, slowly push the sampler into the material. Be careful not to penetrate beyond the surface layer.
- For reusable samplers, extract and eject the sample into a container. Wet-wipe the tube and plunger. For single-use samplers, extract, wet-wipe the exterior, and cap it.
- Label the container.
- Clean debris using wet towels and discard them in a plastic bag.
- For surfacing material, use latex paint or a sealant to cover the sample area. For pipe and boiler insulation, use a nonasbestos mastic.

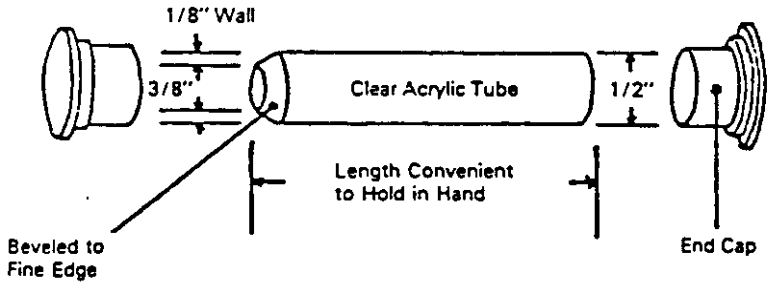


Figure G-1 - Sampler/container

G.2 Selecting a Qualified Laboratory

The U.S. Environmental Protection Agency (EPA) runs a bulk asbestos sample quality assurance program. Updated lists of participating laboratories, their performance scores, and further information on the program are available from the Asbestos Technical Information Service at (800) 334-8571 (Extension 6741).

[1] The guidelines are based on information in John T. Jankovic, "Asbestos Bulk Sampling Procedure," American Industrial Hygiene Association, 46, B-8 to B-10, 1985.

Appendix H. Definition and Description of Factors for Assessing the Need for Corrective Action*

H.1 Condition of the Asbestos-Containing Material

H.1.1 Factors 1 and 2: Deterioration or Delamination and Physical Damage

An assessment of the condition should evaluate: the quality of the installation, the adhesion of the friable material to the underlying substrate, deterioration, and damage from vandalism or any other cause. Evidence of debris on horizontal surfaces, hanging material, dislodged chunks, scrapings, indentations, or cracking are indicators of poor material condition.

Accidental or deliberate physical contact with the friable material can result in damage. Inspectors should look for any evidence that the asbestos-containing material has been disturbed: finger marks in the material, graffiti, pieces dislodged or missing, scrape marks from movable equipment or furniture, or accumulation of the friable material on floors, shelves, or other horizontal surfaces.

Asbestos-containing material may deteriorate as a result of either the quality of the installation or environmental factors which affect the cohesive strength of the asbestos-containing material or the strength of the adhesion to the substrate. Deterioration can result in the accumulation of dust on the surface of the asbestos-containing material, delamination of the material (i.e., separating into layers), or an adhesive failure of the material where it pulls away from the substrate and either hangs loosely or falls to the floor and exposes the substrate. Inspectors should touch the asbestos-containing material and determine if dust is released when the material is lightly brushed or rubbed.

If the coated surface "gives" when slight hand pressure is applied or the material moves up and down with light pushing, the asbestos-containing material is no longer tightly bonded to its substrate.

H.1.2 Factor 3: Water Damage

Water damage is usually caused by roof leaks, particularly in buildings with flat roofs or a concrete slab and steel beam construction. Skylights can also be significant sources of leaks. Water damage can also result from plumbing leaks and water or high humidity in the vicinity of pools, locker rooms, and lavatories.

Water can dislodge, delaminate, or disturb friable asbestos-containing materials that are otherwise in good condition and can increase the potential for fiber release by dissolving and washing out the binders in the material. Materials which were not considered friable may become friable after water has dissolved and leached out the binders. Water can also act as a slurry to carry fibers to other areas where evaporation will leave a collection of fibers that can become suspended in the air.

Inspect the area for visible signs of water damage, such as discoloration of or stains on the asbestos-containing material; stains on adjacent walls or floors; buckling of the walls or

*The information in this Appendix is taken, with modification, from: Brandner, W. October 1982. *Asbestos Exposure Assessment in Buildings Inspection Manual.* Kansas City, MO: U.S. Environmental Protection Agency, Region VII.

floors; or areas where pieces of the asbestos-containing material have separated into layers or fallen down, thereby exposing the substrate.

Close inspection is required. In many areas, staining may occur only in a limited area while water damage causing delamination may have occurred in a much larger area. In addition, the water damage may have occurred since the original inspection for friable material, causing new areas to become friable and require a reinspection.

Delamination is particularly a problem in areas where the substrate is a very smooth concrete slab. Check to see if the material "gives" when pressure is applied from underneath.

H.2 Potential for Disturbance or Erosion

H.2.1 Factor 4: Air Plenum or Direct Airstream

An air plenum exists when the return (or, in rare cases, conditioned) air leaves a room or hall through vents in a suspended ceiling and travels at low speed and pressure through the space between the actual ceiling and the suspended ceiling or ducts. The moving air may erode any asbestos-containing material in the plenum. In evaluating whether an air plenum or direct airstream is present, the inspector must look for evidence of ducts or cavities used to convey air to and from heating or cooling equipment or the presence of air vents or outlets which blow air directly onto friable material.

A typical construction technique is to use the space between a suspended ceiling and the actual ceiling as a return air plenum. In many cases, the tiles in the suspended ceiling must be lifted to check if this is the case. Inspection of the air handling or HVAC equipment rooms may also provide evidence (such as accumulated fibers) of the presence of this material in the plenums.

Special attention should be paid to whether frequent activities (such as maintenance) disturb the material in the plenum. It is also important to check for evidence that the material is being released or eroded (i.e., has it deteriorated or been damaged so that the material is free to circulate in the airstream?).

H.2.2 Factor 5: Exposure, Accessibility, and Activity

These three considerations are highly interrelated and have been combined into a single factor. In general, for a site to show a high potential for disturbance, it must be exposed (visible) and accessible, and be located near movement corridors or subject to vibration.

The amount of asbestos-containing material exposed to the area occupied by people will contribute to the likelihood that the material may be disturbed and determines whether the fibers can freely move through the area. An asbestos-containing material is considered exposed if it can be seen. For a material not to be exposed, a physical barrier must be complete, undamaged, and unlikely to be removed or dislodged. An asbestos-containing material should be considered exposed if it is visible, regardless of the height of the material.

If the asbestos-containing material is located behind a suspended ceiling with movable tiles, a close inspection must be made of the condition of the suspended ceiling; the likelihood and frequency of access into the suspended ceiling, and whether the suspended ceiling forms a complete barrier or is only partially concealing the material.

Asbestos-containing material above a suspended ceiling is considered exposed if the space above the suspended ceiling is an air plenum. Suspended ceilings with numerous louvers, grids, or other open spaces should be considered exposed.

If friable asbestos-containing material can be reached by building users or maintenance people, either directly or by impact from objects used in the area, it is accessible and subject to accidental or intentional contact and damage. Material which is accessible is likely to be disturbed in the future.

Height above the floor is one measure of accessibility. However, objects have been observed embedded in ceilings 25 feet or more high. Nearness of the friable asbestos-containing material to heating, ventilation, lighting and plumbing systems requiring maintenance or repair may increase the material's accessibility.

In addition, the activities and behavior of persons using the building should be included in the assessment of whether the material is accessible. For example, persons involved in athletic activities may accidentally damage the material on the walls and ceilings of gymnasiums with balls or athletic equipment. To become fully aware of occupants' use of the building, the inspector should consult with building staff or personnel.

When assessing activity levels, consider not only the movement caused by the activities of people but also movement from other sources such as high vibration from mechanical equipment, highways, and airplanes. Another source of vibration is sound, such as music and noise, which sets airwaves in motion at certain frequencies. As these sound waves impact on asbestos-containing material, they may vibrate the material and contribute to fiber release. Therefore, more fibers may be released in a music practice room or auditorium than in the rest of the building.

The amount of activity of the occupants can best be described by identifying the purpose of the area as well as estimating the number of persons who enter the area on a typical day.

H.2.3 Factor 6: Change in Building Use

A planned change in the use of the building from, for example, a junior to a senior high school may imply significant changes in the potential for erosion or disturbance. Of particular note is the increased potential for damage from balls to previously inaccessible ceilings in gymnasiums. The addition of machinery (such as dust collectors in wood or metal shops) to a school or office building may introduce vibrations which, again, may be a future cause of concern. The inspector should exercise judgement and draw on experience in evaluating the likely effect of such changes.

Appendix I. Example Building Inspection Form

Room:_____ Sample Number(s):_____

Building:_____ Address:_____

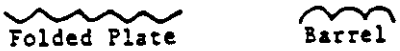
Evaluator:_____ Phone No.:_____

Coated Area: Ceiling Wall(s) Structural Members Above Suspended Ceiling
Pipe Lagging Boiler Insul. Other:_____

Type of Ceiling: Concrete 3 Coat Plaster System Suspended Metal Lath
Concrete Joists and Beams Tile Suspended Lay-In Panels
Metal Deck Corrugated Steel Steel Beam or Bar Joists

Ceiling Height:_____ft.

Ceiling Shape: Flat Dome Other (draw):



Type of Wall (If Coated): Smooth Concrete Rough Concrete Masonry
Plasterboard Other:_____

Amount of Friable Material in Area being Evaluated:_____sq. ft.

Description of Coating: Fibrous (highly friable) Granular/Cementitious (soft) Concrete Like (hard)

Thickness:_____inch(s) Is thickness uniform: Yes No

Coating debris on Floor/Furniture/Work Surfaces: Yes No

Curtains, expandable partitions, etc. being pulled across coating: Yes No

Type of Lighting: Surface Mounted Suspended Recessed

No. of Lights:_____ Type of Heating/Cooling Systems:_____

Type of Floor: Concrete Tile Wood Carpet Other:_____

What is above the room being evaluated?_____

_____

Comments:_____

_____

_____

I.1 Notes to Appendix I

The need for collecting most of the information on this form is discussed in Chapter 5 (Section 5.1). The form requires one additional piece of information: the presence of curtains or expandable partitions which are pulled across asbestos-containing material. Where this situation is found, the curtains or partitions should be removed or repositioned to eliminate contact with the material. Any damage to the asbestos-containing material then can be repaired.

This form was provided by Wolfgang Brandner, the Regional Asbestos Coordinator in Region VII.

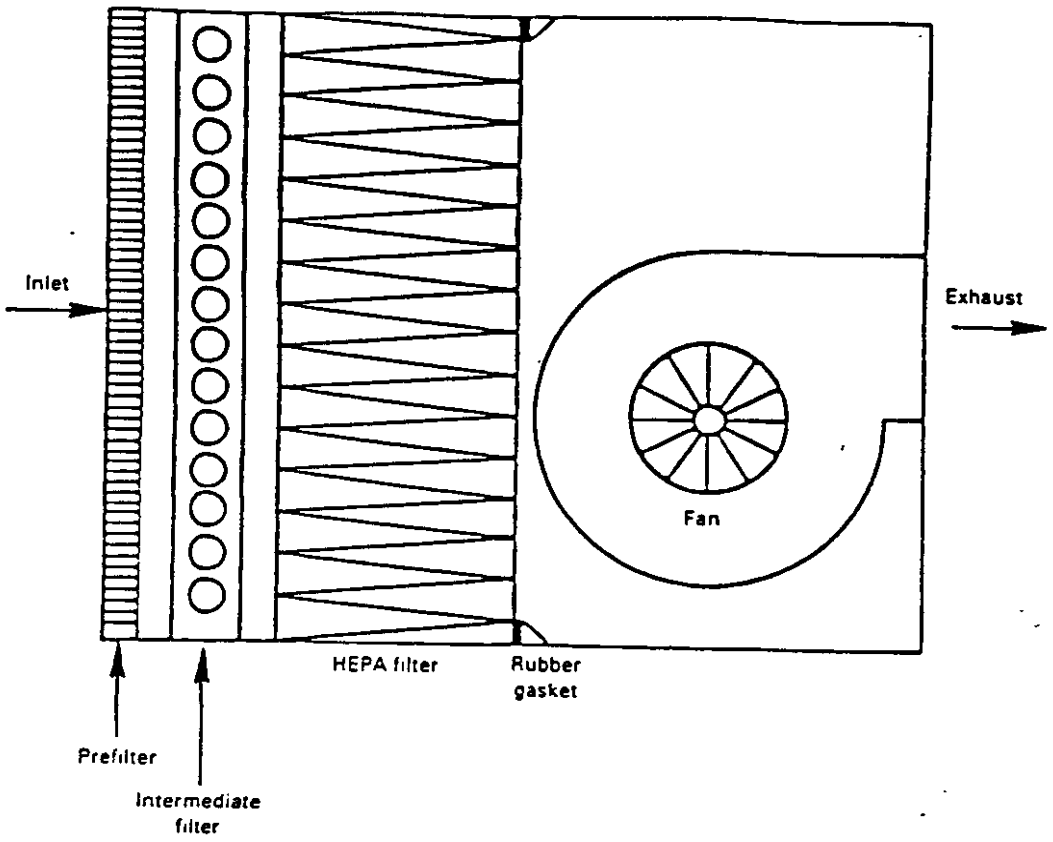


Figure J-1. An example of a HEPA-filtered exhaust unit. This scheme is one of several possible designs.

to replace. The unit should be mounted on casters or wheels so it can be easily moved. It also should be accessible for easy cleaning.

J.2.1.2 Mechanical Specifications

J.2.1.2.1 Fans

The fan for each unit should be sized to draw a desired air flow through the filters in the unit at a specified static pressure drop. The unit should have an air-handling capacity of 1,000 to 2,000 ft^3/min (under "clean" filter conditions). The fan should be of the centrifugal type.

For large-scale abatement projects, where the use of a larger capacity, specially designed exhaust system may be more practical than several smaller units, the fan should be appropriately sized according to the proper load capacity established for the application, i.e.,

$$\text{Total } ft^3/\text{min (load)} = \frac{\text{Volume of air in } ft^3 \times \text{air changes/hour}}{60 \text{ min/hour}}$$

Smaller-capacity units (e.g., 1,000 ft^3/min) equipped with appropriately sized fans and filters may be used to ventilate smaller work areas. The desired air flow could be achieved with several units.

J.2.1.2.2 Filters

The final filter must be the HEPA type. Each filter should have a standard nominal rating of at least 1,100 ft^3/min with a maximum pressure drop of 1 inch H_2O clean resistance. The filter media (folded into closely pleated panels) must be completely sealed on all edges with a structurally rigid frame and cross-braced as required. The exact dimensions of the filter should correspond with the dimensions of the filter housing inside the cabinet or the dimensions of the filter-holding frame. The recommended standard size HEPA filter is 24 inches high x 24 inches wide x 11-1/2 inches deep. The overall dimensions and squareness should be within 1/8 inch.

A continuous rubber gasket must be located between the filter and the filter housing to form a tight seal. The gasket material should be 1/4 inch thick and 3/4 inch wide.

Each filter should be individually tested and certified by the manufacturer to have an efficiency of not less than 99.97 percent when challenged with 0.3-μm dioctylphthalate (DOP) particles. Testing should be in accordance with Military Standard Number 282 and Army Instruction Manual 136-300-175A. Each filter should bear a UL586 label to indicate ability to perform under specified conditions.

Each filter should be marked with: the name of the manufacturer, serial number, air flow rating, efficiency and resistance, and the direction of test air flow.

Prefilters, which protect the final filter by removing the larger particles, are recommended to prolong the operating life of the HEPA filter. Prefilters prevent the premature loading of the HEPA filter. They can also save energy and cost. One (minimum) or two (preferred) stages of prefiltration may be used. The first-stage prefilter should be a low-efficiency type (e.g., for particles 10 μm and larger). The second-stage (or intermediate) filter should have a medium efficiency (e.g., effective for particles down to 5 μm). Various types of filters and filter media for prefiltration applications are available from many manufacturers. Prefilters and intermediate filters should be installed either on or in the intake grid of the unit and held in place with special housings or clamps.

J.2.1.2.3 Instrumentation

Each unit should be equipped with a Magnehelic gauge or manometer to measure the pressure drop across the filters and indicate when filters have become loaded and need to be changed. The static pressure across the filters (resistance) increases as they become loaded with dust, affecting the ability of the unit to move air at its rated capacity.

J.2.1.3 Electrical

J.2.1.3.1 General

The electrical system should have a remote fuse disconnect. The fan motor should be totally enclosed, fan-cooled, and the nonoverloading type. The unit must use a standard 115-V,

single-phase, 60-cycle service. All electrical components must be approved by the National Electrical Manufacturers Association (NEMA) and Underwriter's Laboratories (UL).

J.2.1.3.2 Fans

The motor, fan, fan housing, and cabinet should be grounded. The unit should have an electrical (or mechanical) lockout to prevent the fan from operating without a HEPA filter.

J.2.1.3.3 Instrumentation

An automatic shutdown system that would stop the fan in the event of a major rupture in the HEPA filter or blocked air discharge is recommended. Optional warning lights are recommended to indicate normal operation, too high of a pressure drop across the filters (i.e., filter overloading), and too low of a pressure drop (i.e., major rupture in HEPA filter or obstructed discharge). Other optional instruments include a timer and automatic shut-off and an elapsed time meter to show the total accumulated hours of operation.

J.3 Setup and Use of a Negative Pressure System

J.3.1 Preparation of the Work Area

J.3.1.1 Determining the Ventilation Requirements for a Work Area

Experience with negative pressure systems on asbestos abatement projects indicates a recommended rate of one air change every 15 minutes. The volume (in ft^3) of the work area is determined by multiplying the floor area by the ceiling height. The total air flow requirement (in ft^3/min) for the work area is determined by dividing this volume by the recommended air change rate (i.e., one air change every 15 minutes).*

$$\text{Total } ft^3/\text{min} = \text{Volume of work area (in } ft^3)/15 \text{ min}$$

The number of units needed for the application is determined by dividing the total ft^3/min by the rated capacity of the exhaust unit.

$$\text{Number of units needed} = [\text{Total } ft^3/\text{min}]/[\text{Capacity of unit (in } ft^3)]$$

J.3.1.2 Location of Exhaust Units

The exhaust unit(s) should be located so that makeup air enters the work area primarily through the decontamination facility and traverses the work area as much as possible. This may be accomplished by positioning the exhaust unit(s) at a maximum distance from the worker access opening or other makeup air sources.

Wherever practical, work area exhaust units can be located on the floor in or near unused doorways or windows. The end of the unit or its exhaust duct should be placed through an opening in the plastic barrier or wall covering. The plastic around the unit or duct should then be sealed with tape.

*The recommended air exchange rate is based on engineering judgment.

Each unit must have temporary electrical power (115V AC). If necessary, three-wire extension cords can supply power to a unit. The cords must be in continuous lengths (without splice), in good condition, and should not be more than 100 feet long. They must not be fastened with staples, hung from nails, or suspended by wire. Extension cords should be suspended off the floor and out of workers' way to protect the cords from damage from traffic, sharp objects, and pinching.

Wherever possible, exhaust units should be vented to the outside of the building. This may involve the use of additional lengths of flexible or rigid duct connected to the air outlet and routed to the nearest outside opening. Windowpanes may have to be removed temporarily.

If exhaust air cannot be vented to the outside of the building or if cold temperatures necessitate measures to conserve heat and minimize cold air infiltration, filtered air that has been exhausted through the barrier may be recirculated into an adjacent area. However, this is not recommended.

Additional makeup air may be necessary to avoid creating too high of a pressure differential, which could cause the plastic coverings and temporary barriers to "blow in." Additional makeup air also may be needed to move air most effectively through the work area. Supplemental makeup air inlets may be made by making openings in the plastic sheeting that allow air from outside the building into the work area. Auxiliary makeup air inlets should be as far as possible from the exhaust unit(s) (e.g., on an opposite wall), off the floor (preferably near the ceiling), and away from barriers that separate the work area from occupied clean areas. They should be resealed whenever the negative pressure system is turned off after removal has started. Because the pressure differential (and ultimately the effectiveness of the system) is affected by the adequacy of makeup air, the number of auxiliary air inlets should be kept to a minimum to maintain negative pressure. Figure J-2 presents examples of negative pressure systems denoting the location of HEPA-filtered exhaust units and the direction of air flow.

J.3.2 Use of the Negative Pressure System

J.3.2.1 Testing the System

The negative pressure system should be tested before any asbestos-containing material is wetted or removed. After the work area has been prepared, the decontamination facility set up, and the exhaust unit(s) installed, the unit(s) should be started (one at a time). Observe the barriers and plastic sheeting. The plastic curtains of the decontamination facility should move slightly in toward the work area. The use of ventilation smoke tubes and a rubber bulb is another easy and inexpensive way to visually check system performance and direction of air flow through openings in the barrier. Another test is to use a Magnehelic gauge (or other instrument) to measure the static pressure differential across the barrier. The measuring device must be sensitive enough to detect a relatively low pressure drop. A Magnehelic gauge with a scale of 0 to 0.25 or 0.50 inch of H_2O and 0.005 or 0.01 inch graduations is generally adequate. The pressure drop across the barrier is measured from the outside by punching a small hole in the plastic barrier and inserting one end of a piece of rubber or Tygon tubing. The other end of the tubing is connected to the "low pressure" tap of the instrument. The "high pressure" tap must be open to the atmosphere. The pressure is read directly from the scale. After the test is completed, the hole in the barrier must be patched.

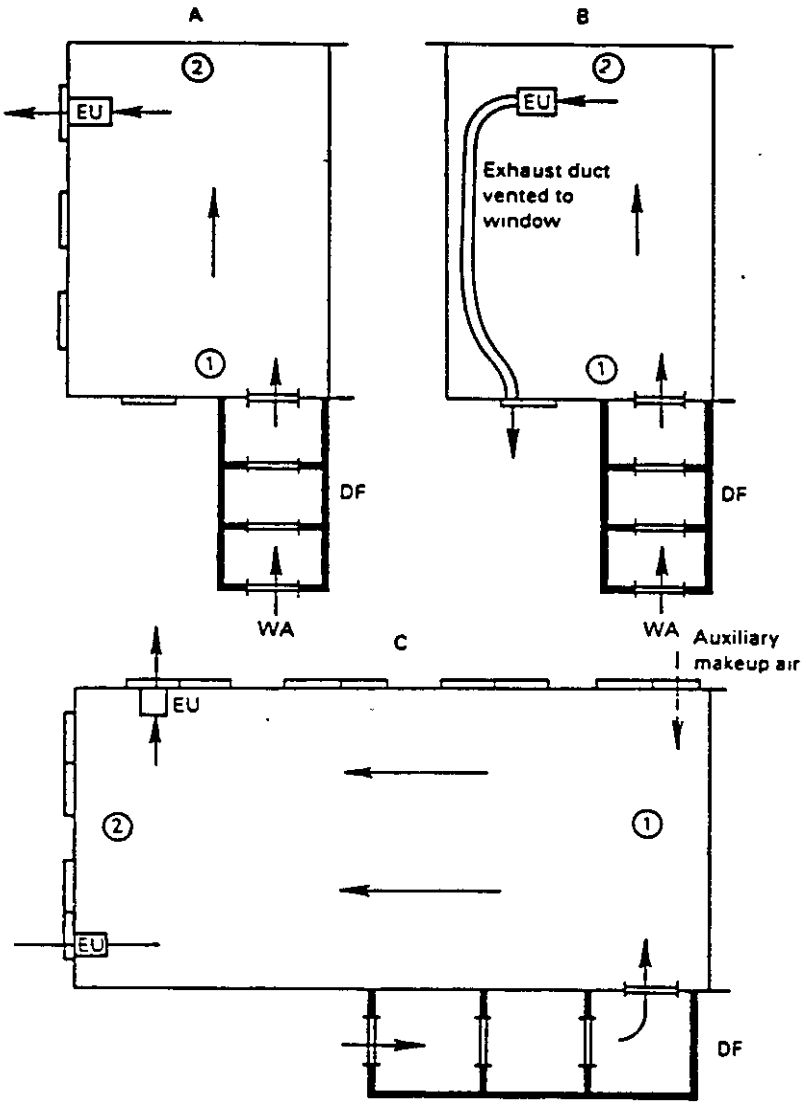


Figure J-2. Examples of negative pressure systems. DF, Decontamination Facility; EU, Exhaust Unit; WA, Worker Access; A, Single-room work area with multiple windows; B, Single-room work area with single window near entrance; C, Large single-room work area with windows and auxiliary makeup air source (dotted arrow). Arrows denote direction of air flow. Circled numbers indicate progression of removal sequence.

The HEPA filter should be replaced if prefilter and/or intermediate filter replacement does not restore the pressure drop across the filters to its original clean resistance reading or if the HEPA filter becomes damaged. The exhaust unit is shut off to replace the HEPA filter, which requires removing the prefilter first, then opening the intake grill or filter access, and finally removing the HEPA filter from the unit. Used HEPA filters should be placed in a sealable plastic bag (appropriately labeled) and disposed of as asbestos waste. A new HEPA filter (structurally identical to the original filter) should then be installed. The intake grill and intermediate filter should be put back in place, the unit turned on, and the prefilter positioned on the intake grill. Whenever the HEPA filter is replaced, the prefilter and intermediate filter should also be replaced.

When several exhaust units are used to ventilate a work area, any air movement through an inactive unit during the HEPA filter replacement will be into the work area. Thus, the risk of asbestos fiber release to the outside environment is controlled.

Any filters used in the system may be replaced more frequently than the pressure drop across the filters indicates is necessary. Prefilters, for example, may be replaced two to four times a day or when accumulations of particulate matter become visible. Intermediate filters must be replaced once every day or so, and the HEPA filter may be replaced at the beginning of each new project. (Used HEPA filters must be disposed of as asbestos-containing waste.) Conditions in the work area dictate the frequency of filter changes. In a work area where fiber release is effectively controlled by thorough wetting and good work practices, fewer filter changes may be required than in work areas where the removal process is not well controlled. It should also be noted that the collection efficiency of a filter generally improves as particulate accumulates on it. Thus, filters can be used effectively until resistance (as a result of excessive particulate loading) diminishes the exhaust capacity of the unit.

J.3.2.3 Dismantling the System

When a final inspection and the results of final air tests indicate that the area has been decontaminated, all filters of the exhaust units should be removed and disposed of properly and the units shut off. The remaining barriers between contaminated and clean areas and all seals on openings into the work area and fixtures may be removed and disposed of as contaminated waste. A final check should be made to be sure that no dust or debris remain on surfaces as a result of dismantling operations.

Appendix K. Checklist for Determining Contractor Qualifications

a. Contractors shall demonstrate reliability in performance of general contracting activities through the submission of a list of references of persons who can attest to the quality of work performed by the contractor.

b. Contractors must demonstrate ability to perform asbestos abatement activities by submitting evidence of the successful completion of training courses covering asbestos abatement. At a minimum, the contractor shall furnish proof that employees have had instruction on the dangers of asbestos exposure, on respirator use, decontamination, and OSHA regulations.

c. Contractors must be able to demonstrate prior experience in performing previous abatement projects through the submission of a list of prior contracts, including: the names, addresses, and telephone numbers of building owners for whom the projects were performed. In rare circumstances inexperienced contractors may be qualified if they can demonstrate exceptional qualifications in the other contractor standards.

d. Additional evidence of successful completion of prior abatement projects should be demonstrated by contractors through the submission of air monitoring data, if any, taken during and after completion of previous projects in accordance with 29 CFR 1910.1001 (e).

e. Contractors must possess written standard operating procedures and employee protection plans which include specific reference to OSHA medical monitoring and respirator training programs. In addition, the contractor must be prepared to make available for viewing at the job site a copy of OSHA regulations at 29 CFR 1910.1001 governing asbestos controls, and Environmental Protection Agency regulations at 40 CFR Part 61, Subpart M, (NESHAPS) governing asbestos stripping work practices, and disposal of asbestos waste.

f. In those States which have contractor certification programs, contractors must possess State certifications for the performance of asbestos abatement projects.

g. Contractors must be able to provide a description of any asbestos abatement projects which have been prematurely terminated, including the circumstances surrounding the termination.

h. Contractors must provide a list of any contractual penalties which the contractor has paid for breach or noncompliance with contract specifications, such as overruns of completion time or liquidated damages.

i. Any citations levied against the contractor by any Federal, State, or local government agencies for violations related to asbestos abatement, shall be identified by contractors, including the name or location of the project, the date(s), and how the allegations were resolved.

j. Contractors must submit a description detailing all legal proceedings, lawsuits or claims which have been filed or levied against the contractor or any of his past or present employees for asbestos-related activities.

k. Contractors must supply a list of equipment that they have available for asbestos work. This should include negative air machines, type "C" supplied air systems, scaffolding, decontamination facilities, disposable clothing, etc.

Appendix L. Guide Specifications for Abatement Projects

The following organizations have developed contract specifications that can be used as a guide for abatement projects:

Association of the Wall/Ceiling Industries—International, Inc.
Guide Specifications for the Abatement of Asbestos Release from Spray- or Trowel-Applied Materials in Buildings and Other Structures. December 1981. The Foundation of the Wall and Ceiling Industry, 25 K Street, N.E., Washington, DC 20002 USA.

Maryland State Department of Health and Mental Hygiene
Recommended Contract Specifications for Asbestos Abatement Projects.

Federal Construction Guide Specifications (FCGS): 02085. Asbestos Abatement Procedures.

GSA Guide Specifications PBS (PCD): 02085. Asbestos Abatement Procedures.

Appendix M. Detailed Specifications for Sampling and Analyzing Airborne Asbestos

The following specifications are summarized from "Measuring Airborne Asbestos Following an Abatement Action" (USEPA 1985).

M.1 Sampling

M.1.1 Sampling Equipment

Standard sampling equipment consists of a pump (operated at a 2 to 12 liter per minute flow rate), a filter in a cassette and associated tubing and supports. Three types of filters can be used:

PCM — cellulose ester with 0.8 to 1.2 μm pore size;

TEM — polycarbonate with 0.4 μm pore size (preferred); or cellulose ester with 0.8 μm pore size.

M.1.2 Number of Samples

M.1.2.1 TEM

A minimum of five samples inside and five outside the work site is recommended. When a negative air pressure ventilation system has been used during the abatement operation the "outside" samples should be collected outside the work site, but inside the building. This provides a comparison between the work site and the incoming air. If a negative air pressure ventilation system has not been used, the "outside" samples should be collected outdoors. These sample sizes are based on calculations of statistical reliability and on the following characteristics:

- The coefficient of variation for TEM measurements is between 100% and 150% based on data from EPA research studies.
- A false positive rate of .10 (i.e., based on the statistical test comparing inside and outside measurements, 10% of the "clean" work sites will fail and have to be recleaned).
- A false negative rate of at most .10 (i.e., the statistical test comparing inside and outside measurements will identify at least 90% of the sites that must be recleaned).

M.1.2.2 PCM

A minimum of five samples is recommended. A sample size of five controls the false negative error rate. At least 90% of the sites where the actual fiber concentration exceeds 0.01 f/cc will fail the test. If the actual concentration is 0.02 f/cc the probability of failure is 99%.

M.1.3 Location of Samplers

M.1.3.1 Indoors

Indoor samplers should be placed so they are not influenced by unusual air circulation patterns. Avoid corners of rooms and obstructions (like furniture). Within the above constraints, samplers should be placed at random around the work site. For example, if the site is a single room of 1000 or more sq. ft., the five samplers should be distributed in an approximately uniform manner. If the site includes more than five rooms, the rooms to be sampled may be selected randomly. The companion EPA document (USEPA 1985) describes this procedure in more detail.

When TEM is used for the air test and a negative air pressure ventilation system has been employed during the abatement operation, the five "outside" samplers should be placed outside the work site but inside the building, and the negative air system left running during sampling. These outside samplers should be located to avoid any air that might escape through the containment barriers. Minimum recommendations are at least 50 ft. from the entry portal to the work site, or 25 ft. from the plastic containment barriers.

M.1.3.2 Outdoors

If TEM is to be used for the air test and a negative air pressure ventilation system has not been used during abatement, then five samplers should be placed outdoors. These should be placed at ground level (about 2 meters high), if possible, and away from obstructions that may influence wind patterns. If access to electricity and concerns about security dictate a roof-top site, do not place samplers near vents or other structures on the roof.

M.1.4 Sampling Volumes

M.1.4.1 TEM

The required sampling volume for the TEM air test is calculated from the theoretical detection limit of the TEM analysis procedures, and from typical levels of asbestos against which measurements in the work site will be compared:

$$\text{Volume} = \frac{(1\ \text{f/10 grid squares})}{(0.005\ \text{f/cc})} \times \frac{(855\ \text{mm}^2)}{(0.0056\ \text{mm}^2)} \times \frac{(1\ \text{liter})}{(1000\ \text{cc})} = 3054\ \text{liters}$$

Where:

- 1 f/10 grid squares (the maximum recommended filter counting area) is the smallest number of fibers needed to make a non-zero measurement. (This is below the limit of reliable quantification.)
- 0.005 f/cc is a typical outdoor asbestos level in urban areas, as measured by TEM (Chatfield 1983).
- 855 mm^2 is the collection area of a 37 mm diameter filter.
- 0.0056 mm^2 is the area of each grid square (75 μm per side) in a 200 mesh electron microscope grid. This value will vary from 0.0056 to 0.0081 mm^2 for different grids. Larger grid squares will improve measurement accuracy for the same sampling volume.

This equation is appropriate for TEM analysis using a direct sample transfer technique (see Section M.2.1). If an indirect technique is used, the required sampling volume is increased in proportion to the dilution used. For example, if the sample is diluted by a factor of 10, the required volume is 10 times larger.

M.1.4.2 PCM

The equivalent PCM limit of reliable quantification for a sampling volume of 3000 liters is:

$$\text{Quantification Limit} = \frac{(10\ f/100\ \text{fields})}{(3000\ \text{liters})} \times \frac{(855\ mm^2)}{(0.003\ mm^2)} \times \frac{(1\ \text{liter})}{(1000\ cc)} = 0.01\ f/cc$$

Where:
- 10 f/100 fields is the limit of reliable quantification for the P&CAM 239 method.
- 855 mm^2 is the collection area of a 37 mm diameter filter.
- 0.003 mm^2 is the size of a typical field of view for a PCM microscope. This value will vary from 0.003 to 0.006 mm^2 for different microscopes. Larger fields of view will improve (decrease) the limit of reliable quantification.

By increasing the sampling volume, the PCM test criterion can be made proportionally more stringent:

Volume	Quantification Limit
3000 liters	0.01 f/cc
5000	0.006
7500	0.004

If the sampling scheme associated with the new NIOSH 7400 PCM method is used, the limit of reliable quantification will be lower for the same sampling volume.

M.1.5 Aggressive Sampling

Procedures for sampling aggressively are:

- Before starting the sampling pumps, direct the exhaust from forced air equipment (such as a 1 horsepower leaf blower) against all walls, ceilings, floors, ledges and other surfaces in the room. This should take at least 5 minutes per 1000 sq. ft. of floor.
- Place a 20-inch fan in the center of the room. (Use one fan per 10,000 cubic feet of room space.) Place the fan on slow speed and point it toward the ceiling.
- Start the sampling pumps and sample for the required time.
- Turn off the pump and then the fan(s) when sampling is complete.

M.2 Analysis

M.2.1 TEM

Use the update to the EPA provisional method (Yamate 1984). The sample should be transferred directly from the polycarbonate filter to the electron microscope grid. If high levels of organic materials are suspected or found, cellulose ester filters and indirect transfer (involving ashing, sonicating, and refiltering the fibers) is recommended. However, levels of airborne organic particles should be low in a cleaned work site.

M.2.2 PCM

Use the NIOSH P&CAM 239 method (NIOSH 1979). The newer NIOSH 7400 methods can also be used, although OSHA has yet to replace P&CAM 239 with 7400 for workplace compliance monitoring. NIOSH reports that 7400 is at least as accurate as P&CAM 239.

M.3 Interpretation of Results

M.3.1 TEM

Use student's "t" test to compare inside and outside levels.

- Compute the natural logarithm of fiber concentration for each sample.
- Compute means of the log transformed data for inside samples and outside samples.
- Form the ratio

$$T = \frac{\bar{y}_1 - \bar{y}_2}{S\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Where:

$\bar{y}_1$ = average of log concentrations inside the work site

$\bar{y}_2$ = average of log concentrations outside the work site

$S = [(\Sigma(y_{1i}-\bar{y}_1)^2 + \Sigma(y_{2i}-\bar{y}_2)^2)/(n_1+n_2-2)]$

n_1 = number of samples collected inside the work site

n_2 = number of samples collected outside the work site

Then compare T to the 95 percentile point of a "t" distribution with $n_1 + n_2 - 2$ degrees of freedom. (When 5 samples are collected inside and outside the 95 percentile point is 1.86.) If T exceeds the 95 percentile point, reclean. Otherwise, release the contractor.

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Appendix N. Glossary

Abatement	Asbestos control beyond a special operations and maintenance program.
Asbestos	A group of naturally occurring minerals that separate into fibers. There are six asbestos minerals used commercially: Chrysotile, Amosite, Crocidolite, Anthophyllite, Tremolite, and Actinolite.
Cementitious	Friable materials that are densely packed and nonfibrous.
Containment	Isolation of the work area from the rest of the building to prevent escape of asbestos fibers.
Delaminate	To separate into layers. As used here, to separate from the substrate.
(Human) Exposure	The presence of people in an area where levels of an airborne contaminant are elevated. A more technical definition sometimes found in scientific literature is: The total amount of airborne contaminant inhaled by a person, typically approximated by the product of concentration and duration.
(Material) Exposure	The amount or fraction of material visible.
Fibrous	Spongy, fluffy, composed of long strands of fibers.
Friable	Capable of being crumbled, pulverized, or reduced to powder by hand pressure.
Homogenous (Material)	Similar in appearance and texture.
Homogenous (Work Site)	Contains only one type of asbestos-containing material and only one type of abatement method was used.
Peak levels	Levels of airborne contaminant which are much higher than average and occur for short periods of time in response to sudden release of the contaminant.
Prevalent levels	Levels of airborne contaminant occurring under normal conditions.
Resolve	To distinguish different objects with a microscope.
Risk	The likelihood of developing a disease as a result of exposure to a contaminant.

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